# SCIENTIFIC AMERICAN MONTHLY

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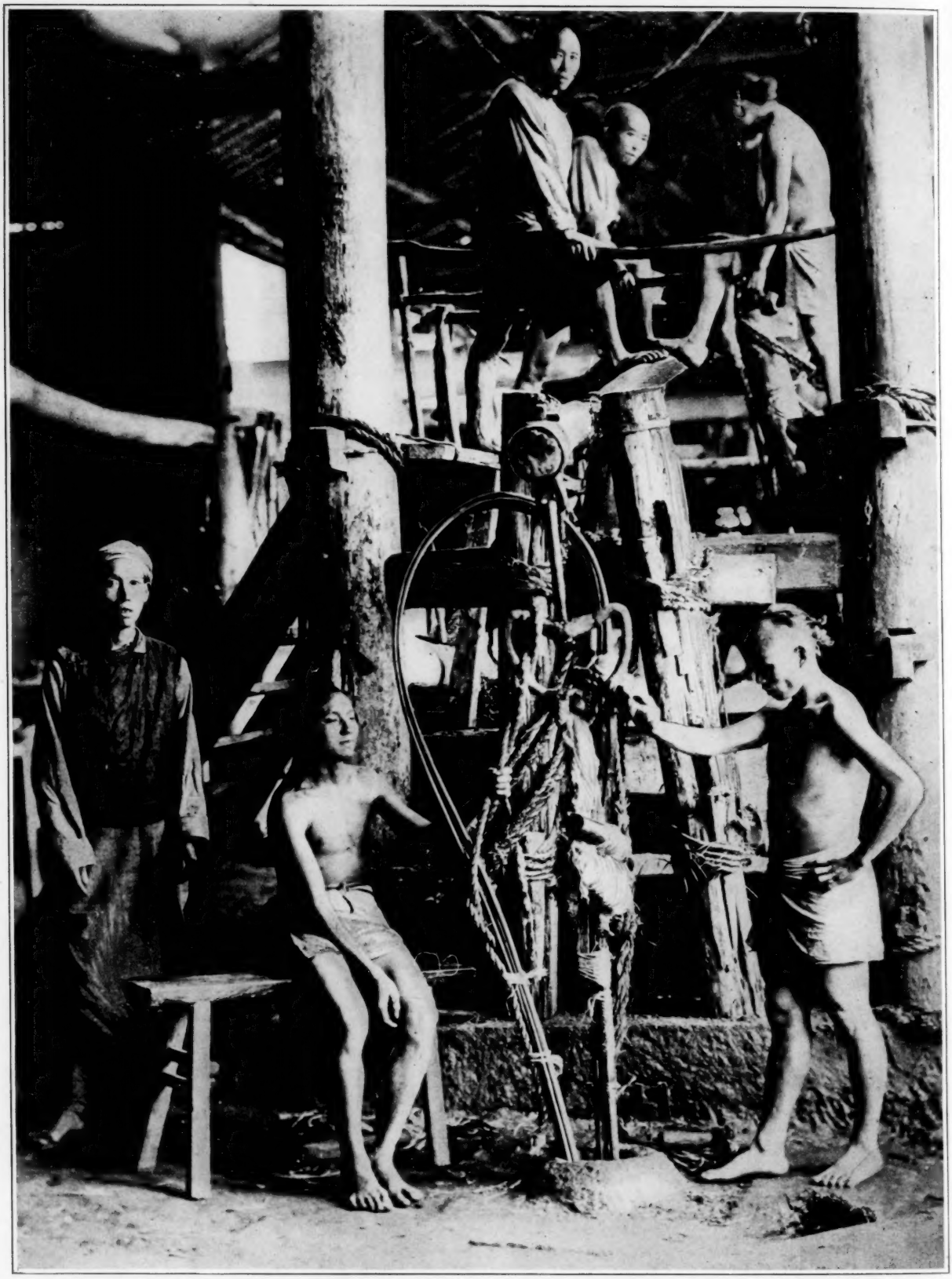

THE SALT WELLS OF CHINA—DRILLING A SALT WELL AS THE CHINESE HAVE DONE IT FOR CENTURIES
(SEE PAGE 427)

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## TO OUR READERS

THIS is a plea for counsel. We are trying to perform a real service to our readers—to produce a journal that will be indispensable to the lover of science and to the man who would keep abreast of the progress of technology. How nearly this purpose is fulfilled we can only tell by hearing from our readers.

Were our field confined to a single branch of science, it would be a simple matter to keep pace with all the latest developments, but we are trying to cover the whole realm of science. The avenues of research are so many and varied, progress is so rapid, there is so much to crowd into our limited number of pages, that we must ever struggle with the problem of what to leave out. Our choice would be better guided if we knew what subjects were of superior interest to the majority of our readers.

Accordingly, dear reader, will you not give us the benefit of your criticism and advice? Tell us what branch of science interests you most. What subjects would you like to see treated at greater length? Is there any field which, in your opinion, we are neglecting, or to which we are devoting too much space? Do you read the SCIENTIFIC AMERICAN MONTHLY for the pure love of science and progress? Do you derive any industrial or commercial benefit from it?

Constructive criticism is invaluable to an editor. Answers to the questions we have put will help us to produce a journal which will be of highest interest and real service to you.

## THE MENACE OF THE HORSEHAIR SHAVING BRUSH

THIS world seems to be getting more and more dangerous to live in. We are beset on all hands with enemies, the deadliest of which are minute organisms visible only with the aid of a powerful microscope. Some indeed, we suspect, are so small that even the microscope fails to reveal them. In most cases we do not even know which of the infinite varieties of bacteria are our enemies. Only a few as yet have been definitely identified. Their insidious methods of attack and the subtle means by which they gain admittance to our bodies are so many and varied that absolute exclusion is well-nigh impossible. The precautions we must take to guard against their invasions are growing more and more irksome and have added materially to the complexity of living.

One of the first of these minute organisms to be isolated was the anthrax bacillus. The chief field of operation of these militant microbes is in the bodies of herbivorous animals, both domestic and wild, and through the domestic animals, the bacteria gain access to man. Indeed, anthrax used to be a dread scourge of human populations until proper sanitary precautions were taken and adequate means developed for combating the disease.

Recently an unusually large number of cases of anthrax were reported in New York City and a search was instituted to discover the breach through which the deadly germs had broken in. Eventually the search narrowed to an apparently innocent toilet article, the shaving brush. To be sure shaving brushes in insanitary barber shops will carry disease from one patron to another, but here the case was much more flagrant. New brushes that had not previously been used served as the medium for introducing the dread disease. The brushes were of a cheap class made from horsehair. Examination of the brushes revealed the fact that they carried the spores of anthrax. Evidently the hair had been taken from diseased animals and had not been properly sterilized. The shaving brush although the chief offender was not the only one; other brushes also stood convicted with the criminal evidence upon them. Fully 80 per cent of the brushes tested were found to carry anthrax, and the spores were also discovered upon cloth and braid made of horsehair. Articles made from hog bristles are not liable to be infected because the process of treatment which they undergo removes the contamination.

During the war a great many hides were brought into New York City, and also a large amount of horsehair, which evidently had not been thoroughly inspected. Out of thirty-four cases of anthrax in New York City, eighteen were traced to the use of infected shaving brushes, and of these nine were fatal. In addition to this there were a number of operatives in factories who were infected with the disease during the manufacture of shaving brushes, and also in the treatment of hides. One case was traced to the use of a table crumb brush, which proved to be infected with spores of anthrax.

As a result of these cases the Board of Health of the City of New York has adopted regulations requiring that all hair used in the manufacture of brushes and cloth be sterilized under processes prescribed by the Board. The sale of brushes is also forbidden without having the word "sterilized" permanently and clearly branded upon the article and this word cannot be applied to the article until it has been sterilized under the direction of the Board of Health.

The spores of anthrax are particularly difficult to destroy. They resist ordinary disinfecting; they will actually pass through tanning and bleaching solutions and still retain their activity. Mercuric chlorid, 1:2500, with 1 per cent of formic acid has been used to destroy the germs, also forty-eight hours' exposure to 2 per cent hydrochloric acid with 10 per cent sodium chlorid, but these measures have not yet been proved absolutely reliable.

In view of the difficulty of destroying the spores, and also in view of the difficulty of eliminating contaminated horsehair from the market there is need for a national prohibitive act banishing horsehair shaving brushes, and requiring all manufacturers using horsehair thoroughly to sterilize the product before making it into toilet articles.

# Infinitely Small and Infinitely Great

## Lengths, Volumes, Masses, Velocities, Etc., at the Limits of Measurement

By Georges Estoppey

INFINITELY small! Infinitely great! This subject is so vast that we shall describe it superficially only. To give all details, to explain how the following values have been determined, would be impossible within the limits of an article such as this.

Logically speaking, the infinitely small is inconceivable and has no limit. Similarly, the infinitely great is immeasurable and has also no limit. But, in the following description, we shall be more tolerant with these two expressions, and we shall apply the term "infinitely small" to particles or corpuscles susceptible of being analyzed, and we shall apply the term "infinitely great" to masses or distances susceptible of being measured. We shall try to give an idea of the size of everything which is around us, in comparing them as much as possible with the size of man, with his power, with the speeds he has attained with his swiftest vehicles.

*RELATION OF THE INFINITELY SMALL TO THE INFINITELY GREAT*

*The Meter Taken As Unit*

| | |
|---|---|
| *0,000.000,000,000,000,001* | *Diam. positive nucleus* |
| *0,000,000,000,000,001* | *Diam. negative electron* |
| *0,000.000,000,001* | *Diam. of atom* |
| *0,000,000,001* | *Length of ultra violet waves* |
| *0,000,001* | *Micron* |
| *0,001* | *Diam. of a mite* |
| *0.1* | *Diam. of an orange* |
| *1* | *METER=39.37 INCHES* |
| *300* | *Eiffel tower height* |
| *8,890* | *Altitude of Himalayas* |
| *24,000* | *Diam. of the smallest asteroid* |
| *3,500,000* | *Diam. of the moon* |
| *12,700,000* | *Diam. of the earth* |
| *384,000,000* | *Dist. from earth to the moon* |
| *150,000,000,000* | *Dist. from earth to the sun* |
| *8,880,000,000,000* | *Diam. of Neptune's orbit* |
| *40,000,000,000,000,000* | *Dist. earth to α Centauris* |
| *430,000,000,000,000,000* | *Dist. from earth to polar star* |
| *2,000,000,000,000,000,000* | *Dist. from earth to the farthest star situated at the limit of the Milky Way* |
| *4,500,000,000,000,000,000,000* | *Dist. from earth to the nearest nebula situated outside of the Milky Way* |
| *100,000,000,000,000,000,000,000* | *Dist. from earth to the farthest nebula* |

*The last number is only an estimated value since it cannot be measured exactly*

If we look only superficially at what we see around us, it seems that man takes the most important place in the universe. Let us not pride ourselves on such a high conception, but let us search, let us analyze, let us try to lift the mysterious veil of nature—in this alone may we take pride.

Now let us speak of the most infinitesimal objects known. Let us first observe a minute drop of clear water through the lenses of a powerful microscope. What shall we see? Millions and millions of infusoria which are circulating with tremendous speed.

Concerning the atom, which was for a long time considered the smallest particle of matter, do you know how many atoms there are in a pin head? Eight thousand of billions of billions! 8,000,000,000,000,000,000,000—and this is not yet the limit since the atom is composed of a great number of electrons which represent the most infinitesimal particles that man can measure. And now, what is the size and power of man as compared with the size and power of these minute particles? Infinitely great, shall we say? . . . Never mind; man is only infinitely small compared with objects around him. And then, our terrestrial globe; how does it compare with man? Infinitely great would we say? Not at all. This earth on which we dwell, this earth which evolved in boundless space through millions and millions of years, is but a particle of sand in our planetary system, and our planetary system is only an imperceptible point lost in the immensity of our stellar system and this system no matter how extensive it may be, is still infinitely small as compared with the universe which is infinite.

Now that we have an approximate idea of the subject which will be described in the following lines, we shall go into further details.

The subject will be divided into several chapters. The first one will treat of lengths in which we shall speak about the diameter of the electron, of the atom, of the earth, and of the sun. We shall also speak about the distances from the earth to the farthest stars and nebula. The next chapter will deal with the subject of speed, energy, calorific and luminous powers, weights, time, inter-atomic energy and of smallest organic corpuscles. We shall also say something about the physiological effects produced by the number of sounds and luminous waves. Then, we shall try to give an idea of the enormous dimensions of space that can be detected by the most powerful telescope and, finally, we shall establish the relation between the minima and the maxima that man can measure. And when we shall have paved all the steps of the enormous chains which bind the infinitely small to the infinitely great, we may conceive of the space that man occupies in the universe.

### LENGTHS

Let us take as our standard the meter (39.37 inches) which is one ten millionth part of a quarter of a terrestrial meridian.

Meter = 1.

The millimeter which is equal to $\frac{1}{25}$ of an inch is one thousandth part of a meter.

$$1 \text{ millimeter} = \frac{1}{1000}$$

This dimension will no doubt appear very small to persons who are not accustomed to such small fractions.

The "micron" represents the millionth part of a meter

$$1 \text{ micron} = \frac{1}{1{,}000{,}000}$$

The micron is the linear unit that physicists use to determine the length of luminous waves. The symbol of the micron is represented by the Greek letter $\mu$. The lengths of waves of the visible spectrum varies from 0.4 $\mu$ to 0.8 $\mu$. The ultra violet rays have a wave length of 0.1 $\mu$. These dimensions may seem to be the limit of the infinitely small that can be conceived. Never mind. This value is still very large as compared with atom which is the smallest particle of ponderable matter. The atom, the diameter of which is $10^{-8}$C is ten thousand times smaller than the micron.

$$\text{Diameter of the atom} = \frac{1}{10{,}000{,}000{,}000} \text{ of a meter.}$$

This exceedingly small dimension is still one hundred million times larger than the positive electron (nucleus) this particle of which the diameter is $10^{-16}$C is the one billion billionth part of a meter.

Such is the smallest dimension that man is able to determine by mathematical and experimental deductions. Is it possible to conceive of such a tenuous particle? To obtain a meter we must put side by side one billion billions of such a particle. Let us try to give an idea of this enormous number. Supposing that a man counted this number at a rate of one million per second; he would have to live not less than ten thousand years to complete the count.

Let us proceed in the opposite, taking again the meter as a base of our comparison

Meter = 1

The highest building in the world is the Woolworth Building which reaches a respectable height of 270 meters. The Eiffel Tower in Paris measures 300 meters. The highest mountain in the world is Mt. Everest which raises his head to an altitude of about 8,890 meters. The greatest depth measured in the Pacific Ocean is about at 9,000 meters deep. The diameter of the earth is 12,700,000 meters. Supposing that an airplane is flying consecutively at a speed of 200 miles an hour, it would take a little more than 5 days for this airplane to make a single trip around the earth, the circumference of which is 40,000,000 meters. The distance from the earth to the moon is 380 million meters. The diameter of the sun is about 3.6 times larger than the distance from the earth to the moon or 1,380 million meters. It would take more than 1½ years for our airplane to fly around the sun. The distance from the earth to the sun is 150 billion meters. To make the circuit of Neptune's orbit, the diameter of which is about 9 thousand billion meters, our airplane would have to keep going for 3,500 years. Alpha Centauris, the nearest star, is 4½ light years distant from us or 42 millions of billions of meters (42,000,000,000,000,000). The large and magnificent nebula of Andromeda has a diameter which measures 386,500 times the distance from the earth to the sun. It takes about 6 years for light to cross this space. The distance is equal to 58 millions of billions of meters (58,000,000,000,000,000). It would take more than 23 million years for our airplane to pass through this nebula which is about 6,000 times larger than our planetary system. The polar star is 46½ light years from us, and its distance is equal to 440 millions of billions meters (440,000,000,000,000,000). The light of the farthest star, at the confines of the Milky Way, is taking about 2,000 years to come to us. This star is shining at a distance equal to 18 billions of billions meters (18,000,000,000,000,000,000). The giant star Betelgeuse, the diameter of which is 300 times larger than that of our sun is at a formidable distance of 180 light years. And that is not yet the limit of distance which can be perceived. A powerful telescope searches spaces at a much greater distance. Let us go out of our stellar system and let us see what is outside the Milky Way. The nearest nubula belonging to the stellar system that is nearest to ours is at more than 45,000 light years from the earth, or at about 400 billions of billions meters (400,000,000,000,000,000,000). And at last, the farthest nebula that the telescope permits us to perceive is estimated by Dr. Prud'honme to be at a distance of something like several millions of light centuries from our earth. Let us be satisfied with a distance of 10 million light years, which is sufficiently formidable for us. Figured in meters, this distance would be equal to 90 thousand billion billion meters (90,000,000,000,000,000,000,000). Let us try to gain an idea of such a fantastic number. The sun is 150 billion meters from us and seems very far away. Do you know how much time it requires for light to travel this distance? Only 8 minutes and 13 seconds. It would take about 8 hours and 20 minutes for light to pass through the planetary system: about 4,000 years to leap across our stellar system and more than 10 million years to traverse the distance to the farthest nebula that the telescope permits us to observe. And there are certainly other nebulæ still farther away, and probably millions and millions of stellar systems like ours evolving in the infinite space that we shall never be able to perceive.

Four hundred and ninety-three light *seconds!* Such is the distance from the earth to the sun. Ten million light *years!* Such is the greatest distance from the earth to the farthest nebula that we are able to discern. The comparison of these two numbers gives us an idea of the immensity of the space that this telescope can fathom. If that distance of 10 million light years represents a feeble part of the infinite, what is the size of the universe?

### SPEED

Let us take the unit per hour as a base of speed. The average speed of a pedestrian is about 4 miles per hour. The maximum speed reached by a passenger express train is about 80 miles an hour. The most rapid airplane flies with a speed of 200 miles an hour; this is the maximum speed which can be attained by man. The utmost speed obtained by mechanical power does not exceed 2,400 miles per hour, which is the speed of a rifle bullet. The earth moves along its orbit with a speed of about 66 thousand miles an hour. The average speed of $\beta$ rays, particles of radium which pass through an aluminum sheet of a few millionth of thickness, varies from 18,000 to 175,000 miles per second. The speed of $\alpha$-rays of radium is about at 18,000 miles per second. The $\gamma$-rays of radium which can pass through a steel sheet of several inches thickness, have a speed of about 180,000 miles per second, or about 650 millions of miles per hour and the utmost speed which can be measured is that of light which is 186,000 miles per second or 670 million miles per hour. What shall we think of this tremendous speed of light when we compare it with our bullet, the speed of which does not exceed 2,400 miles per hour?

### ENERGY

We shall take the horsepower as a unit of energy. One horsepower is the energy which lifts 550 pounds to a height of one foot in one second. One horsepower = 550 foot-pounds per second. The average energy of a man is about 1/10 of one hp. The most powerful locomotive develops 5,000 hp. The most powerful steam turbine in the world develops an energy of 46,000 kw. or about 60 thousands horsepower per unit. The steam engines of the largest battleship furnish 180,000 hp. The kinetic energy of a 15-inch shell produced by its speed at the exit of the gun is about 500,000 hp. The power developed by hydraulic turbines at Niagara Falls exceed 600,000 hp. The total power of Niagara Falls is estimated at about 6 millions hp. A steel sphere 3 feet in diameter revolving at a rate of 1,000 r.p.m. develops the enormous kinetic energy of about 1,600 hp. Applying the same calculations to the earth, the diameter of which is 12,700,000 meters, the kinetic energy produced by its rotation amounts to 300 million billions of billions of horsepower (300,000,000,000,000,000,000,000,000 hp.). The travel of the earth around its orbit produces the formidable energy of about 3 thousand billion billion billion horsepower. (3,000,000,000,000,000,000,000,000,000,000 hp.). The sun, which weighs 325,000 times as much as the earth and which is moving toward the "Constellation of Hercules" with a speed of 240 millions of kilometers per year (150 millions of miles per year) develops by his motion, the enormous power of 20 million billion billion billions of horsepower = (20,000,000,000,000,000,000,000,000,000,000,000 hp.). The sun alone possessing such an energy, what is the total power of our planetary system, and if this system, as previously stated, is only an infinitesimal speck in space, what must be the total energy of the universe!

### CALORIFIC AND LUMINOUS POWER

The unit of heat is the calory. The calory is the quantity of heat necessary to raise 1 kg. of water 1° cent. of temperature. The mechanical equivalent of heat is equal

1 calory = 425 kg./m./s.

The sun, the temperature of which is about 7,500° Cent. develops a calorific power of 100 thousand billions of billions of calories per second. Our little earth absorbs only the 2,300 millionth part, that is to say 40 thousand billion calories each second, which is in itself a very respectable number.

The unit of luminous power is the candle. The luminous intensity of the sun is equal to 1,500 billion billion candles, which represent about 60 billion billion electric lamps of 25 candles each. The earth receives only the 2,300 millionth part of this gigantic light. What shall we think of the searchlight giving only 1 million of candles as compared with the sun, which itself is only a very small unit among the millions that stud the universe.

### ORGANIC CORPUSCLES

The "Ciron," that small mite living in detritus and measuring 1 cubic millimeter or 0.000,064 cubic inch (the size of a sand grain), was in the good old days considered the smallest organism existing. Today the microscope detects an extraordinary world living in a space not larger than that of a mite; 0,000,064 cubic inch of tripoli is composed of more than 2 millions of fossil shells.

Pure water, colorless and odorless, contains about 150 billions of infusoria in a drop not larger than a mite. In observing this drop of water through a powerful microscope, giving an apparent diameter of 12 feet to this drop, you will be surprised to see the intensive life which reigns in such a small space. These corpuscles are so numerous that it would be impossible to insert the point of a pin in a space that is unoccupied: The little animalcules all touch one another, cross one another and devour one another to provide for their existence, and it is possible that there exist still smaller animalcules that we cannot detect with today's microscope. Vinegar which gives so much taste to salad contains a much more considerable number of such corpuscles. Some of the bacteria are so small that about 700 billions of them are necessary to make a gram, some of them give birth to about 16 millions of their species in less than 24 hours. A blood corpuscle, the diameter of which does not exceed 7/1000 of a millimeter (0.000,028 inch) contains not less than 3 billions 600 millions of organic particles. How about the mite if we compare it with these infinitely small animalcules? Nature is as complex in the infinitely small as in the infinitely great.

### PHYSIOLOGICAL EFFECTS

The human ear is accustomed to perceive sounds, the number of which varies from 16 to 33,000 per second. The tone "A" has 435 vibrations per second. The deepest base tone "C" vibrates 62.25 times per second, and the highest soprano tone "C" has 1,044 vibrations per second. The highest tone that the human ear can perceive vibrates 33,000 times per second. If we hear sounds, the vibrations of which vary from 16 to 33,000 times per second, it is because our tympanum is in accordance with that number of vibrations, which is due purely to a physiological disposition. Suppose, for instance, that our ear was accustomed to detect sounds, the number of vibrations of which vary from 33,000 to 34 billions a second, all our musical instruments would be imperceptible to us. We would not hear their music at all, but would be able to hear electrical waves.

Let us, for a moment, consider human sight. Our eyes perceive light, the number of vibrations of which varies from 400 to 700 trillions per second. If our retina were more sensitive and permitted us to perceive vibrations varying between four and five billions of billions per second, we would be transported in a strange world. Our eyes would have a penetrative power similar to the X-rays. In this case all colors would disappear. Taking a walk in the street, we would meet ambulant skeletons. Passing through a forest, we would see no trees, but we would perceive the sap in thin strings rising slowly toward the leaves. With our X-ray eyes, let us go into a house. What shall we see? The windows will be opaque, the walls transparent. To be normal to our strange eyes, the windows should be made of wood or of iron sheet, the walls should be of glass; all the furniture, chairs, tables should be covered with a thin glaze to be seen. Our condition of living would be quite different from that to which we are accustomed.

### TIME

Time like space and force is relative. Time has no limit. The second does not signify anything in itself, this is an absolutely arbitrary base which man has chosen as a time unit.

A second represents the 86400th part of the time taken by the earth to make a complete rotation about its axis, which is a day, and the latter is the 365th part of the time that the earth takes to accomplish a revolution around its orbit which is a year. The average life of a man is about 70 years, which is only 2,200 million seconds. Certain bacteria do not live longer than a fraction of a second. A butterfly lives a few hours. Some scientists suppose that the human life appeared on the earth some tens of thousand years ago, and that organic life appeared about 250 million years ago. The primitive epoch during which the superficial part of the earth has been solidified, is supposed to date back some 500 million years. As the data of appearance of human life and organic life on the earth cannot be verified, the figures above mentioned cannot be taken as correct. If the first foundations of terrestrial crust date back about 500 million years, probably some billions of billions of centuries have elapsed since the planet was detached from the solar nebula, and if that is so, how long ago was the solar nebula founded? Mystery! Time is without limit!

### ATOM AND INTER-ATOMIC ENERGY

The number of hydrogen atoms contained in a 1 cubic millimeter (1/15625 cubic inch) is about 36 millions of billions (36,000,000,000,000,000) and as each atom is composed of 2,000 electrons this makes 72 billions of billions of electron particles contained in such a small space. A pin head contains the enormous number of 8 thousand billion billion atoms (8,000,000,000,000,000,000,000). Let us try to gain some idea of this phenomenal number. Suppose that an atom is represented by a little cube measuring an inch on each side, if we pile these together, we shall have a cube measuring 310 miles on each side. If each atom of this pin head is composed of 1,000 electrons, you can imagine the enormous number of inter-atomic particles contained in the one hundredth part of a gram of metal (1 metric gram is the twentieth part of an ounce).

The kinetic inter-atomic energy produced by the "dissociation" of matter is the work furnished by the speed of the dissociating electric particles contained in the matter. Suppose that this particle moves at an average rate of 62 miles per second, the dissociation of a metric gram would furnish a work of 6 billions 800 millions horsepower (6,800,000,000 hp.). But as the dissociation of matter is exceedingly slow, it would take more than 300,000 million years to liberate all particles, supposing that the dissociation takes place at a rate of one billion particles per second. So, you see, the power liberated in one second would be very small, about $\frac{1}{10}$ thousand of a millionth of a horsepower in the time unit. Let us suppose that this power of 6,800,000,000 horsepower be liberated in one second, this quantity of energy will be sufficient to operate a 500-ton freight train over a distance equal to four times the circumference of the earth. To cover this distance it would be necessary to burn 3 thousand tons of coal which at $10 a ton will cost $30,000. This would be the value of inter-atomic energy contained in one gram of metal if it could be liberated in one second. A sphere 3 feet in diameter possesses an inter-atomic power of 20 millions of billions of horsepower. If we apply the same calculation to our sun, the weight of which is 1,800,000,000,000,000,000,000,000,000,000 tons the inter-atomic energy produced by its dissociation would yield an inconceivable amount of power. Since the sun is but a spark in the stellar system imagine, if you can, what must be the total inter-atomic energy of the universe!

### WEIGHT

Let us take the metric gram which is the 28th part of one ounce as our unit of weight. "A fraction of a milligram

(1/28000 ounce) of radium salt, emitting, without intermission for years and years, some billions of particles each second," said Gustave Le Bon, "will not lose enough of its weight to be measured by an ordinary weighing scale."

Curie's electroscope detects the presence of one thousandth of a billionth of a gram of radium. By the sense of smell we are able to detect a hundredth of a billionth of a gram of iodoform. The spectroscope detects the presence of 3 billionths of a gram of ordinary salt. A liter of clear water weighs 1 kg. or 2.2 pounds. The average weight of a man is about 75 kg. A sphere of metal 3 feet in diameter weighs about 3,200 kgs. The earth weighs 5,500 billion billion tons (5,500,000,000,000,000,000,000 tons). The sun, which weighs 325,000 times more than the earth, would tip the scales at 1,800,000,000,000,000,000,000,000,000 tons. The total weight of all planets does not exceed the 700th part of the weight of the sun.

SUMMARY

The most tenuous corpuscle that man has determined by experimental and mathematical deduction is the positive electron which is the smallest particle of matter. The electron, the diameter of which is $10^{-16}$ cent. has a volume of 0.000,000,000,000,000,000,000,000,000,000,000,000,001 cubic millimeter (1 cubic millimeter $= \frac{1}{15625}$ cubic inch). The atom has a volume of 0.000,000,000,000,000,000,001 cubic millimeter. Let us try to compare these two numbers with a small ball one centimeter in diameter (1 cent. $= \frac{1}{2.5}$ inch). Suppose the atom is represented by the earth, our electron would have a diameter of about 5 inches and the small ball would take the formidable proportion of a sphere whose diameter would measure about 50 light days, that is to say about 140 times the diameter of Neptune's orbit. In this case the diameter of the ball will have the proportion of 130,000,000,000,000 meters. Judge now the smallness of the electron! The volume of the earth is 1,000 billion cubic kilometers. The volume of the sun is more than one billion billion cubic kilometers. Suppose our stellar system were of spherical form with a diameter of 4,000 light years, the space occupied by this sphere would attain the enormous number of 32,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000 km³. Now, let us consider the farthest nebula that we can detect, and which is estimated to be at 10 million light years, from us. Suppose that were the radius of a sphere embracing all that it is possible to see. The space occupied by this sphere would have the enormous value of a cubic kilometer multiplied by 5 followed by a trail of 60 zeros. If our stlelar system was reduced to the volume of the earth and the space above considered were reduced in the same proportion, its diameter would be nearly equal to that of Neptune's orbit.

Now, that you have some figures before you, try to imagine the dimensions of the electron, try to conceive the space that we are able to detect with the telescope. And let us finally establish the relation between these two extremes, which gives the most formidable number that man can imagine which is number 5 followed by 123 zeros. Inconceivable, isn't it? However this is not yet the limit! The enormous space that we are able to detect with powerful telescopes which is infinitely great relative to the infinitely small electron represents only a small part of the infinite space of the universe. The universe is infinite! The universe contains an infinite number of bodies which appear, evolve and disappear, followed by other forms which again appear, evolve and disappear, and so forth, accomplishing infinitely the same cycle in the infinite space through infinite time.

# The Smallest Animal in Existence

## An Account of the Results of Some Recent Studies of the Minutest Creature in the World

By Leon Augustus Hausman, Ph.D.

IN every wayside ditch and watering trough, in pools, streams, rivers, lakes, seas, and oceans, in fact, in all waters on the surface of the earth there exists a vast host of animal forms, invisible to the unaided eye, known as the protozoa. The interest which attaches to these minute forms is related to their meager size, primitive structure, and to the probable fact that these forms represent the first embodiment of animal life which arose on our earth.

We are accustomed to think of animal bodies as fairly complex structures, *i.e.*, composed of various tissues and organs. The different organs in a complex animal body are made up of tissues, and these, in turn, are composed of cells, tiny units of structure, invisible, for the most part, to the naked eye, and comparable to the bricks which go to make up a building.

The protozoan body can hardly be said to be composed of cells, in the plural, for the entire body is itself but a single one of these unitary animal parts. For this reason the protozoa are said to be unicellular.

A large majority of the protozoa lie below the range of vision of the human eye. Indeed but three or four species only can be discerned without the aid of the microscope, and these only when placed on a glass slip and held in strong light against a black background. Even these forms are extremely minute, the largest of them, known as *Dileptus gigas*, being only about 1/60 of an inch in length! Most of the species lie below 1/254 of an inch along their longest dimension.

It is to this group of protozoa, or first animals, for that is what their Greek name means, that there is found what is, up to the present state of our knowledge, the smallest animal form in existence. This Lilliputian of the animal world is commonly but 1/5,000 of an inch in diameter, and the writer has found many indiviuals which measured but 1/12,700 of an inch! A photograph of this creature, which rejoices in (or more probably is happily ignorant of) the name of *Pleuromonas jaculans*, a name signifying the one-sided darting creature, is shown in Fig. 2. In form, the body is usually kidney-shaped, with a definite, thin cuticle investing the whole, and almost transparent. Within the body there can sometimes be distinguished minute granules. From the shallow depression in one side of the body there arise two long filamentous appendages, known as flagella, or whips. It is by lashing these from side to side, or up and down, that the creature makes its irregular progress through the water, or possibly draws food material toward the base of the whips. Mouth there seems to be none, but since the animal often lies with its concave side closely pressed up against a mass of bacteria, or putrescing material, it may be supposed that particles of food adhere to the rather viscous protoplasm (cell substance) and are withdrawn into it. This is known to be the manner of feeding of several other of the protozoa, closely related to the *Pleuromonas*.

In making its progress through the water, *Pleuromonas* moves with a series of rapid darts and jerks, and then comes suddenly to rest. But even its resting periods are not periods of entire immobility, for all minute particles, suspended in a liquid, exhibit a rapid vibratory or quivering movement, which is caused by the incessant bombardment of molecules of the surrounding liquid. This movement is known as the Brownian Movement (or pedesis) from its discoverer. All particles suspended in a liquid like water, show this movement, if their

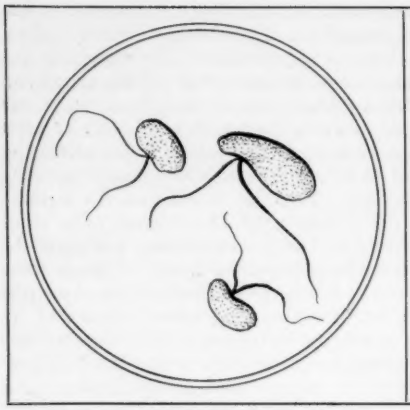

FIG. 1. A GROUP OF PLEUROMONAS IN CHARACTERISTIC ATTITUDE

FIG. 2. A PLEUROMONAS LYING AMID DEBRIS—ENORMOUSLY MAGNIFIED

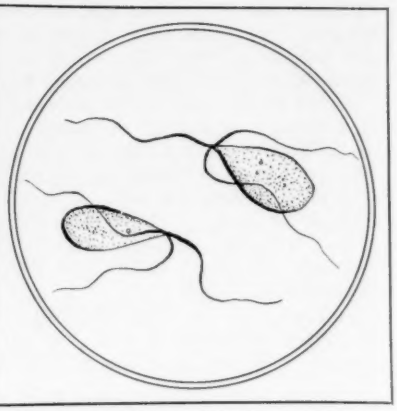

FIG. 3. ELVIREA CIONAE, A CLOSE RELATIVE OF PLEUROMONAS

diameters are less than 1/500 of an inch. The less the diameter of any particle, the more pronounced its agitation. Hence part of the characteristic motion of our little *Pleuromonas* is an entirely involuntary one.

*Pleuromonas*, together with many of its relatives of scarcely larger size, inhabits pools and ditches wherein plant material is decomposing. The presence of putrefactive bacteria seems to be a *sine qua non* of its existence.

How great a range of magnitude and complexity exists in the animal world is strikingly presented to the mind when one considers the latitude which separates such an animal as the *pleuromonas* from some of the earth's animal Titans. The *Gigantosaurus*, for example, is described by an English scientist, Prof. Ray Lankester, as totaling 120 feet from nose to tail! This is a length over 18 million times greater than the smallest of the *Pleuromonas!* Another interesting comparison is the relative weights of the *Pleuromonas*, and one of our modern mammals, the heaviest creature which ever lived, the great Sibbald's whale (*Balaenoptera sibbaldii*). This titanic creature is estimated to weigh not less than 150 tons! From computations made by the writer, the weight of one of the smallest specimens of *Pleuromonas* would lie in the neighborhood of one one-hundred thousandth gram. Thus relations in weight between the animals that lie at the very antipodes of avoirdupois is as 1 to 14 trillion!

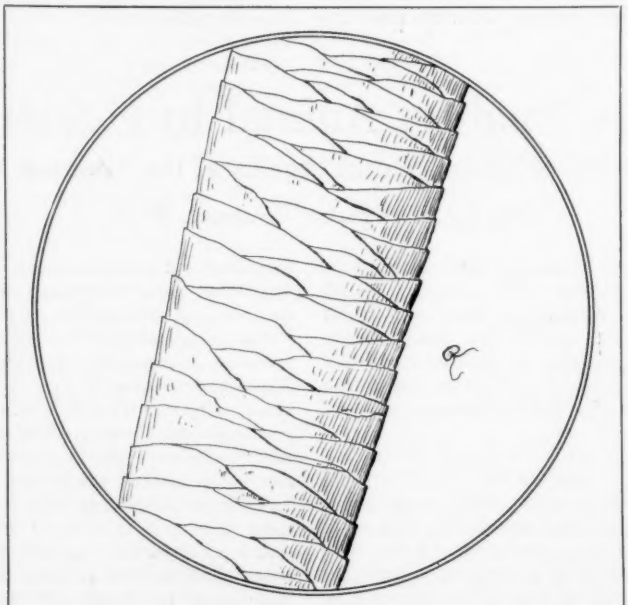

FIG. 4. PLEUROMONAS JACULANS, COMPARED WITH AN AVERAGE HUMAN HAIR

It is not alone because of our interest in the zoölogically curious that scientists are lead to make studies of the *pleuromonas* and of its near relatives, the *Mastigophora*, or whip-bearers, but because the study of these minute forms of life leads to a clearer conception of what life itself is; how the cell, which is the unit of all life, plant as well as animal, behaves, and what it is capable of when existing alone. Furthermore the economic importance of these minute creatures, like that of their equally minute plant relatives, the bacteria is very great. Areas of water containing *pleuromonas* are often colored a milky hue by the vast numbers of individuals present. Each of these countless millions of animals is engaged, and busily so, in transforming what would otherwise be dangerous decaying substance, into animal protoplasm, by feeding. These minute creatures are, then, scavengers, and the work which they accomplish together may be of considerable importance. For they convert putrescence into a form in which it serves as food for larger protozoa and tiny crustaceans, and thus they perform a real service in keeping in our waters a supply of food for the larger forms, such as fishes.

## VOICE IN YOUNG AND ADULT BIRDS

SOME very curious studies have been made by two German ornithologists named Stadler and Schmitt, regarding a change of voice in certain kinds of birds, from youthful to adult tones. While this is lacking in most birds it is so marked in others that it may be fairly compared with the so-called change of voice in boys. This marked transformation is found in young buzzards among which the sounds uttered by the young are about an octave higher than those of the older birds. In certain owls the call of the young is even as much as 1½ and 2 octaves higher. In the young domestic duck and in some owls the tones are ¼ higher than the voice of the father.

Young moor larks and finches exhibit an actual break in the voice—that of the fledglings being harsh and unmusical. In young domestic fowls this break or change is very marked.

It often happens indeed that after the birds have reached a certain stage in their development both voices may be heard almost at the same time in the same individual. Then the young voice is silent and the adult voice gets the upper hand.

In some birds, which have a youthful plumage which differs from that of the adult, there seems to be a certain connection between the change in voice and in the coloring of the feathers—this is certainly the case in the silver gull.—From *Kosmos* (Berlin).

# The Sterlingbush Calcite Cave*

## Difficult Problems Solved in Reconstructing the Cave in the New York State Museum

By Noah T. Clarke

IT may be of interest to museum workers with their many problems in common, to know something of the story of the remarkable grotto now housed in the State Museum.

Several years ago in a quarry at Sterlingbush, Lewis County, N. Y., an opening of some 4 feet in diameter was revealed after blasting. This opening proved to be a puncture in the wall of a grotto which broadened out to 10 feet in width and 5 feet in height and extended back for 20 feet to a narrow vault of 4 feet in diameter, continuing on a gradual slope downward for 20 feet more and terminating in an inaccessible and almost perpendicular crevice. Realizing that in the course of quarrying operations the crystal contents of this grotto must be destroyed, it was decided to remove them to a place of permanence where the public might have access to an exhibit as near like the original as practicable. On account of the size of the crystals the task of removal and safe shipment of some 14 tons was a tremendous undertaking. Some of them weighed as much as a thousand pounds and each, whether large or small, was a perfect geometric development of calcium carbonate delicately colored by manganese to an amethyst in reflected light and pink in transmitted light.

*From the Report of the Director of the New York State Museum (1918).

The problem of reconstruction was ahead and careful detailed study of the project had to be assumed and worked out by those skilled in many arts. A blind closet about 8 feet square beneath an arch in the mineral hall seemed a likely place for such an exhibit but the difficulty in this was to obtain in such a small space the depth required by the original cave. After much experiment it was found that by placing upright a plate glass mirror 18 by 24 inches at the farthest left-hand corner of the closet and at an angle of 46° to the observer and also a second mirror 14 by 34 inches, tipped back slightly and hidden from view in a proposed recess on the right directly opposite the first mirror, we could produce an apparent depth of 25 feet and a gradual slope down to a narrow passage, as in the original. With this arrangement the spectator could not see his own image or the ordinary visitor detect a mirror.

The iron frame work which was to support the weight of the crystals was built of 1¼ inch angle iron and, in order to relieve the great strain on the museum floor, suspended from a roof girder by a seven-eighths inch iron rod with a turnbuckle.

The form of this frame was determined by making a full-size ground plan of the closet and by bending thin strips of wood into the shape of the intended iron ribs. There were

THE STERLINGBUSH CALCITE CAVE AS RECONSTRUCTED IN THE STATE MUSEUM AT ALBANY, NEW YORK

fifteen of these ribs which met at the center of the roof and were bolted in place to a large circular iron plate. The general shape of the completed framework was that of an irregular dome with a false floor built of 2-inch angle iron 20 inches above that the museum floor. The object of this was to place the visitor in a more intimate relation to the exhibit by bringing the crystals into greater prominence. An opening 2½ feet square was provided in the front of the iron work to allow for a window for the observer.

Our attention was devoted for nearly two months to preparing the crystals for exhibit and working out a method to fasten them to the walls and roof. There was a secondary or stalactitic formation over many of the crystals which was removed by applying dilute hydrochloric acid with a jeweler's brush, always exercising great care in order to confine the acid to the particular spots where there was crust, so as not to injure the fine sharpness of the angles and the exposed faces of the clear crystals.

To suspend calcite in large and bulky crystals from the ceiling and in every conceivable position at any angle was the proposition now before us. If one has had the experience of drilling a fine calcite crystal and had it fly into a half dozen pieces he can imagine the discouragement of having several hundred crystals before him to be drilled accurately, some to have three and four holes each. This was exactly the problem. We devised an individual clamp which would have held the weight of the crystal but to make a special clamp for each separate specimen would have been impracticable on account of the area of crystal faces concealed and the expense and time required to make them. Further experimenting with flat drills nine thirty-seconds of an inch and seven thirty-seconds of an inch diameter of Stubb's English steel, hardened in water and drawn to a straw color, used in a lathe turning at a slow speed of about 400 revolutions a minute, proved to be a successful method to obtain results. This way we were able to obtain a steady motion and apply a gradual and even pressure, so essential in overcoming the difficulty of boring through many cleavage planes which were always a constant source of trouble. With this procedure, out of all the lot, just two crystals failed us. Thin slabs composed of clusters of small crystals were drilled entirely through. An iron bolt with a loop at one end was fastened in these holes by means of a nut and washer on both the face and back of the specimen. The exposed nut on the face of these clusters was easily hidden by matching a small crystal over it. The larger specimens, however, were bored for a depth of only 2 inches and in each hole was set a 1⅞ inch screw eye; the heaviest crystals necessitating special heavy irons of the same shape. By pouring melted sulphur in the hole and immediately plunging into it a red hot screw eye, we had a means of support, when cold, by which the crystals could be wired in any position to the iron framework. Many times the distance between the iron ribs was too great and necessitated spanning these spaces with three-fourths inch or 1¼ inch band iron.

The actual placing in position of the crystals was started at the deepest point, which was around the mirror. Small areas of the frame were covered as needed with galvanized iron wire screen of one-fourth inch mesh. After a crystal had been securely wired to the framework, a combination of cheesecloth and plaster woven over the wires and frame between the screen and crystal held it permanently in the exact position desired. This same process was continued gradually around the sides and roof to the window.

Each time a crystal was placed there were three points to consider: Did it fit exactly to the one next to it? Were the best crystal faces seen, not only looking directly at it but in each of the two mirrors? Was it possible to place behind it an electric light which could not be seen from three sides? These questions arose simultaneously nearly every time and the solution was simply the answer given by trying out each of them.

The construction of the floor was the last and comparatively the easiest operation. Two-inch spruce planking was laid over the floor girders to carry this great weight as the largest crystals of the original cave were found on the bottom, many of them entirely free on all sides and apparently with no surface of attachment. For this reason it was not necessary to place these so close together, which gave a good deal of leeway for electric lights with shades.

We have carefully shaded a system of twenty-one lights ranging from 10 to 60 watt, which have been placed behind the most highly colored crystals. The astonishing effect of glowing soft colors by so transmitting the light could not be achieved in any other way, and although this condition could not be found in nature, the aid of a little intensified light certainly brings out and emphasizes the exquisite beauty which would otherwise lie dormant or be lost.

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## LIVING PLANTS IN SOLID ROCK

IT seems almost incredible that living vegetation should have been found thriving in what to all outward appearances is solid rock. Yet this has been proved to be an actual fact. A German scientist, Diels, making a study of the algæ which grow within the crevices of the Dolomites of the Southern Tyrol, discovered upon splitting open the hard, living rock having no crevice visible to the eye through which light, air, or moisture might penetrate, thriving layers of algæ arranged beneath the surface. "Almost every blow of the hammer," writes Herr Diels, "revealed such vegetation, which is entirely invisible from without. The zone of growth varies in depth from 4 mm. to 8 mm. where the surface of the rock above is bare. When the surface is covered, however, with vegetation, the stone-dwelling algæ are found nearer the surface, at from 1 mm. to 2 mm. in depth, since modest as their wants may be they require a certain degree of light to enable them to grow."

These stone-dwelling algæ are of more than one kind and are arranged in zones or bands according to the amount of light which they require. Humble as these plants are they are of considerable importance in the scheme of things, since they assist the other forces of nature, such as frost, earthquakes, and changes of temperature, to break up the living rock and change it into fertile soil for higher forms of vegetation.—Abstracted from *Naturwissenschaftliche Umschau d. Chem. Ztg.*, for November, 1920.

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## STUDYING GLACIERS WITH THE STEREOSCOPE

AT a recent meeting of the French Academy of Sciences (March 7, 1921) an account was given by M. P. L. Lercanton with respect to his study of glaciers by means of stereoscopic views. It is not always possible to place sign posts at the front end of the glacier so as to study the rate of its advance, since in many cases this would require too much time and trouble while in others it might be attended with danger. A direct comparison of a series of successive photographs does not always suffice to show the slighter modifications in the form of the glacier. M. Mercanton consequently conceived the idea of making use of the stereoscope to detect these slight variations. The stereoscope has been used in a similar manner for a long time to detect forgeries or alterations in bank notes as well as by astronomers in searching for comets and small planets.

As applied to glaciers the process is as follows: From the same position and with the same camera two photographs of the front of the glacier are taken, preferably with an azimuth normal to the presumed direction of the variation and at a given interval as of a year, for example. When the two proofs taken at the different times are examined through a stereoscope those areas of the glacier which have been modified will be shown in relief on the portions of the photograph which correspond to motionless objects such as the sky, rocks, etc.

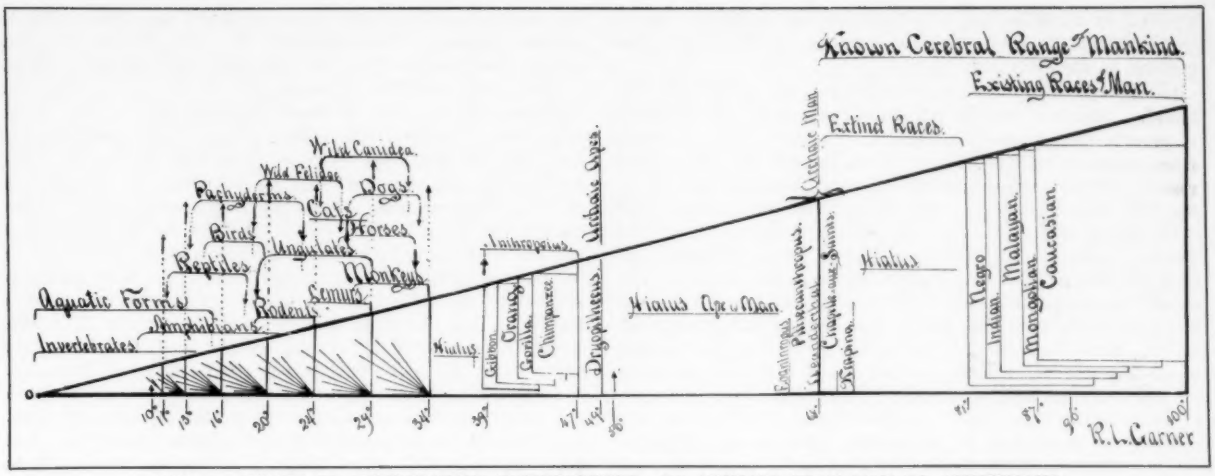



FIG. 1. CHART OF COMPARATIVE INTELLIGENCE OF ANIMALS FROM MAN TO AMPHIBIANS

# The Animal Mind

## The Comparative Intelligence of Animals

### By the late Dr. R. L. Garner

IT is difficult to find a common unit of measure by which to determine with precision the various horizons of the minds of different species of animals. Hitherto it has been chiefly a matter of guesswork, and most people let their fondness for a certain kind of animal bias their judgment. Upon surveying the whole range of animal intelligence, it is apparent that there are many levels, and by comparison it is possible to formulate a system by which they may be graded. The process of accomplishing this is by a study of the environments of a race, its physical development, its mode of life, and by interpreting the actions of its members and the motives which prompt them. In the animal kingdom as a whole there is a wide scope of intelligence, ranging from protozoa to man, in which certain obvious divisions must be made according to their disparity. Probably all minds are the same in quality and compass, and the degrees of difference constitute the problem to be solved.

At a glance it is evident that those forms of life which live under the most restricted conditions are the aquatic and amphibian forms. Shut in by the surrounding waters, aquatic animals have a poor medium through which to receive sense impressions. The element in which they live not only lessens their opportunities of experience, but likewise lessens their need for knowledge of their surroundings. These impressions are, therefore, comparatively few in number and dull in nature, and the resultant development of senses correspondingly less, which places aquatic forms far down the scale of comparative intelligence. For the same reasons amphibians are only a trifle higher in mental horizon.

The advantages of sense development through experience are chiefly with the terrestrial forms of life. Among these the most conspicuous divisions are between those of nocturnal and those of diurnal habits, of which the former suffer in much the same way as the aquatics in restriction of experience, although, obviously, to a much less extent. Diurnal animals, spending their waking hours as they do in the clear light of day, have the greatest opportunities for acquiring new and distinct impressions, and are logically those whose mental attainments stand the highest because of the advantages of frequent use and its consequent development. Aquatic and nocturnal animals receive a measure of protection from the media which restrict their perception of exterior things, and, therefore, have less need for alertness, skill and strategy as means of self-preservation. Many of them tend to develop but sluggish senses and often grow large bodies with comparatively small brains. The *carnivors*, the *pachyderms*, reptiles and lower forms, most of which lead isolated lives and therefore cultivate but little social intimacy with their kind, while their optics are more acute than those of diurnal animals, are yet far below them in the scale of intelligence. Their mental horizon in comparison to that of diurnal animals is as the distance and distinctness of their vision in the surrounding darkness to that of the diurnal animals in the light of day. The *ungulates*, or hoofed animals, are of mixed habits and bear nearly the same relation between the nocturnal and diurnal animals that the amphibians do to aquatic and terrestrial forms. They are inclined, however, to live in herds, instead of family groups, and have only the rudiments of social life. They are strictly herbivorous. They are, perhaps, exposed to more danger from enemies than the carnivorous, but because they band together in greater numbers, their faculties of observation and alertness are less taxed, and their chances of survival upon being attacked are proportionately greater.

As the basis of comparison of animal intelligence, man as the highest type occupies the foreground of a perspective (see Fig. 1) of 100 units, the vanishing point of which is at zero, where protozoan life begins. Inasmuch as we find in man the most active and efficient faculties of mind, it is logical to assume that he possesses the means and qualities which promote the growth and development of all psychic activities. It also seems clear that *those animals which are most highly specialized and, therefore, most resemble man in their physical development likewise most nearly approach his mental horizon.* In the lines of investigation so far pursued, man obviously occupies the highest level, and it appears equally clear that other genera follow him in the same order and degree in their mental status and possess the greatest individual possibilities for advance beyond the normal stage of their kind, and in pursuing further the manifestations of these elusory forces, the validity of the foregoing premises become more and more evident.

According to these it would follow that the manlike apes possess higher mental powers than those of any other group of animals below man, and investigation amply substantiates this conclusion. Through twenty-five years of methodic study of animal life this fact has been borne in upon the writer by such force of evidence, that what was once a theory has long since become a conviction, and the same conclusion is being

reached by all scientists who have devoted sufficient time to the study of the subject with due respect to the weight and cogency of the evidence.

Of the ape group the highest level is occupied by the chimpanzee. This has been clearly demonstrated by the education of certain specimens of this genus. By means of such specimens, educated with laborious care to obtain the most reliable results—differentiating always between *education* and *training*—the writer has demonstrated that the chimpanzee mind is endowed with many powers formerly accorded to man alone. Among these, the perception of abstract values and their relation requires the highest form of mental capacity, and surely constitutes the crucial test of intelligence. Scientists had hitherto believed this power to be entirely above the range of any animal mentality. Yet a young chimpanzee learned to distinguish concrete geometrical forms and pick them out by word of command, in blocks of three dimensions, or upon a plane surface in relief or countersunk. The little ape learned by name and to distinguish between five different colors regardless of the forms they covered.

The crowning accomplishment which bore down all opposition was the ability to count any collection of small objects, such as beads, grapes, nuts, jackstones, or other things which she could handle easily. The chimpanzee did not guess at the numbers, but drew them from a pile, one by one, and counted them in any order up to four, obviously appreciating the numerical value of each number in exactly the same way as a human being does. This was accomplished in four months of teaching, beginning when the animal was one year old. During this period it was found that the difficulty of learning for the chimpanzee mind is not measured simply by the addition of the number of things to be learned. To add digit values to her repertory, for example, the difficulty incident to the process was equivalent to the powers of the number of distinct concepts. In other words, each single thing taught being regarded as one unit of difficulty, to teach her to count *three* was not simply the sum of three units of difficulty, but was *nine* times as difficult, or the square of the number of concepts.

$C + C + C = 3(3D)$

$C =$ concept.

$D =$ difficulty unit.

To cite another case, it was *four* times as difficult to teach the little ape to grasp the idea of *white cube* as it was to teach her the concept of either *white* or *cube*. To teach the idea of *big red cube* was *nine* times as difficult as to teach her any one of the three concepts alone. The difficulty of teaching the chimpanzee mind to perceive and appreciate abstract values advances thus, one- four- nine- and sixteen-fold. Compared with the simple addition, or thereabouts, of the human brain, this shows the relative capacity of the two types of mind.

No other genus below the human has ever accomplished anything to be compared with this chimpanzee. Other specimens of the same genus have displayed unmistakable ability in similar ways, which leads the writer to believe this one to be a fair standard of chimpanzee intelligence. Without betraying any trade secrets, I feel justified in stating here that the horses, dogs and other animals that are alleged to have learned to count, or select certain figures by word of command, are pure and simple products of expert fakery, so far as real education is concerned. I have been associated for many years with the best animal trainers in the profession, and most of them have kept no secrets from me; but it is no injustice to them to say that scientific methods of *teaching* and their methods of *training* are as different as the respective ends sought, the one being strictly scientific—and accurate—the other strictly commercial, without other considerations.

Investigation thus demonstrates that the chimpanzee is next to man in mental endowments, and it will be seen that this genus of ape most resembles him in physical structure, also. The general physical resemblance of the chimpanzee to man is too obvious and too well known to dwell upon here; but in skeletal formation the similarity is still greater. In fact in only two sections does the skeleton of a chimpanzee differ in structure from that of man, viz., in the *sacrum* and the *sternum*, and neither of these discrepancies is very great. With these comparatively trifling exceptions, the skeletons of man and the chimpanzee may be truly said to be exact counterparts of each other, having the same number of bones, of the same general model, arranged in the same order, articulated in the same manner, and performing the same functions. In other words, the corresponding bone in each is the same in design and purposes. The gorilla, which has been found to be next to the chimpanzee in mentality, possesses a skeleton which is a counterpart of that of the chimpanzee in its general structure, save for the cranial ridges in the skull of the adult male. In some respects the gorilla skeleton is slightly less like that of man than the chimpanzee. Somewhat less like man is the ourang-outang both in skeleton and soft anatomy; and his mental possibilities are correspondingly less than those of the gorilla. The gibbon is still more removed from man in these points. His mentality appears to be of a lower type than that of the ourang-outang.

As investigation is carried farther the physical points in common and the variations corresponding approximately to their inferiority, multiply accordingly. Many persons shrink from the thought of man being allied to the ape because of the hirsute of the latter; and yet if a square inch of the skin of an ape be compared under the microscope with the corresponding area on the surface of the human skin, there will be found approximately the same number of hairs on each. Man has probably lost the heavy hair on his body primitive through ages of wearing clothes, just as he has lost the prehensile use of his foot probably from wearing shoes. It has even been found that apes are subject to many diseases of man to which other animals appear to be immune.

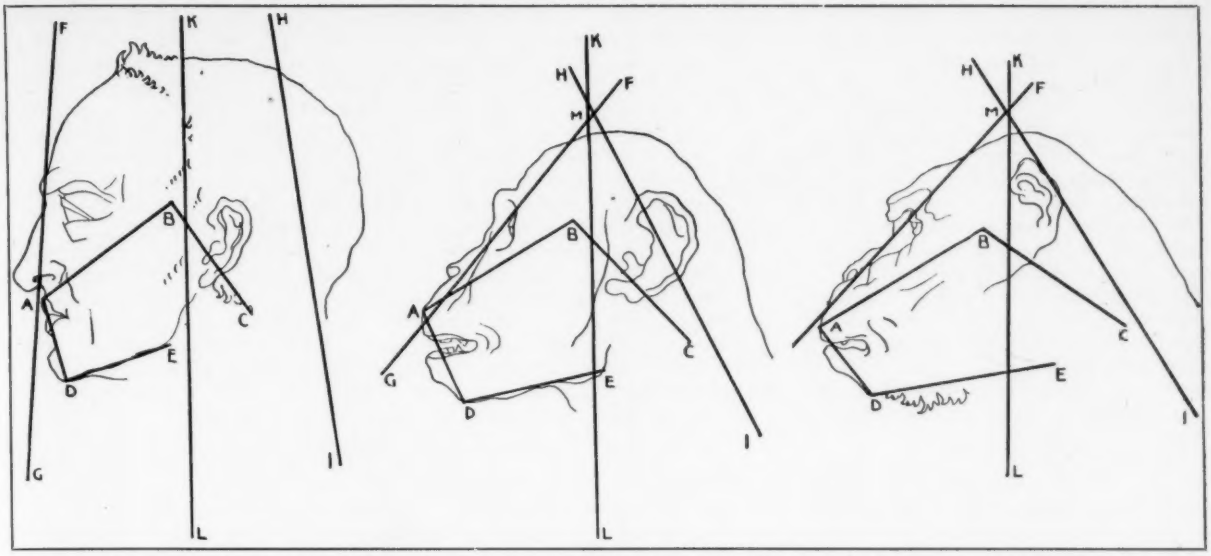
Dr. Reichert of the University of Pennsylvania has performed a vast series of experiments which demonstrate that the blood crystals of the chimpanzee and the gorilla are very much more like those of a human being than they are like any species of monkey known. The chief difference between the human and the ape crystals is a greater obtuseness of certain angles. The axes are almost the same, the geometrical forms are the same, with an equal number of similar facets and angles, and arranged in the same order. In fact they are of the same system.

The clavical, or collar bone, is more developed in apes than in other simians. In the lower species it becomes more and more primitive in form and less uniformly articulated in inverse proportion to the habit of erecting the body either habitually or occasionally, while in lower orders of animals it is hardly articulated at all, being quite rudimentary and probably useless.

In this way the physical resemblance to man may be traced with variations through the entire perspective of animal life, and it would be found to hold essentially true in relation to comparative intelligence.

The diet is another reliable index of the mental horizon of any genus of animals. Those forms which have the most varied diet and which are the most fastidious in selecting and preparing their food, are found to be more highly developed in mentality than those of more simple diet and less discrimination of taste. Multivorous man conforms to this rule even in the different races of his genus. In search of variety of food, animals necessarily range through a wider field of experience, expose themselves to more varied conditions, incur more dangers, which demand greater exercise of their wits to avoid and thus they get a more or less intensive mental training.

It is also an interesting sidelight upon the question of the search for food in relation to animal intelligence, that those animals which dwell in the vicinity of human beings, pitting their faculties against those of man, are mentally superior




FIGS. 2 TO 4. CRANIO-FACIAL ANGLE (*A B C*), GNATHIC ANGLE (*A D E*), FACIAL PLANE (*F G*) AND CERVICAL AXIS (*H I*) OF MAN, COMPARED WITH CHIMPANZEE (*CENTER*) AND LOWER ORDERS OF MONKEYS (*RIGHT*)

to any genus or species that dwells habitually in the sequestered depths of the jungle. Among the anthropoid apes, the chimpanzee has, perhaps, the most varied dietary of any other race, and is about the most fastidious in his choice of food and his manner of eating it. He makes his habitat in the purlieus of human habitations, and much of his food is the fruit of man's toil, which the ape procures by stealth. In company with his family, he makes frequent raids on the gardens and plantations of men, employing tactics which would do credit to the wits of prowling schoolboys intent upon similar adventures. They take narrow chances, often with surprising success. The gorilla also is an adept in this art. His dietary, however, is less varied than that of the chimpanzee. He leads a more retired life, seeking the inaccessible places in the forest for his nightly bivouac, while the chimpanzee often builds his bed in a tree within a few hundred yards of a village, relying upon his own shrewdness to escape harm in this rather dangerous locality. The chimpanzee actually seems to like the proximity of human beings. The ourang-outang, next to the gorilla in mental endowments, takes still fewer chances in procuring his food, lives upon a less varied diet, depends more upon the wild products of the forests, and is more easily satisfied with what he obtains. The gibbon, last and lowest of the ape group, is much more addicted to arboreal habits, is more limited in his dietary and more timid in procuring it. He is much less fastidious in his choice, and comes less frequently in contact with man. In descending the scale of the monkey species, their horizons of mind descend in about the same degrees as they lessen the variety of their diet and their proximity to the dwellings of man. Below the monkeys the same rule holds good of the lemurs, which gradually merge into the *procynors*, including raccoons, civets, etc., which are allied in one direction with the *canidae* and in the other with the rodents.

In following out certain physical developments as coordinates of other faculties it appears that the movements of the digits also coincide with the mental development of all orders and genera. Man possesses some twenty-seven possible movements; the chimpanzee, twenty-three; other apes, twenty-one; monkeys, nineteen; lemurs, eleven; and so on down the scale to the reptiles, with only two, simply those of opening and closing the digits. The rodents, however, do not appear to conform strictly to this law, and in this may be the exception which is supposed to prove a rule, although in other ways they conform to the place to which they are assigned in the scale of nature, as shown in the diagram.

To man the use of the thumb is highly important, and to the ape only a little less so; but as we descend the scale it becomes more and more limited in its use and arrested or atrophied in development until, in forms below the lemurs it becomes a mere rudiment, or "dewclaw." In a few species of monkeys, however (usually of low levels) and prosimians, the thumb is entirely absent. In the *ungulates* it is absent, having been absorbed into the anchylosed carpal and tarsal bones.

The erect carriage of man is, undoubtedly, the result of slow development through the ages. This tendency toward the erect habit in the apes keeps pace with the development of intelligence along the scale of animal life. although it appears at a point above the stage reached by other genera. Through the whole range of simian races this coordination is traceable, although the close alliance of different species of monkeys makes it difficult to discern their exact relative standards of mentality.

In conjunction with this tendency is that of the glottic plane (or plane of the vocal cords) which, beginning with reptiles, occupies a position of approximately forty-five degrees from the axis of the larynx, tends toward the horizontal as we ascend the scale until in the apes it is approaching the horizontal, and in man it is still nearer to that position. The gamut of sounds, or scope of vocal products controlled by the glottis, undergoes similar variations. From man, whose gamut is the most varied of all animals, it is found that the chimpanzee has the most varied gamut of the lower animals, followed in order by the gorilla, gibbon and monkeys. The ourang-outang is possibly an exception. Continuing on down the scale, ultimately ending in the reptilian forms, we find the vocal powers more and more restricted in scope and degraded in quality, until in the lowest reptiles, they are lost in a mere hiss.

This scale of relative variety in gamut is of special importance here, inasmuch as it relates directly to the brain and its higher functions. Vocal sounds are, by their very nature, vehicles of expression, conveying definite concepts. A vocal sound emitted by an animal may or may not be intelligible to the hearer, but its source is not a vacuum, so to speak. In animal economy it is a de facto means of communication. The apes and monkeys have sounds which to their own species stand for ideas. Primitive wants and oft-repeated situation—each has its particular sound or word, which symbolizes it. Hunger, fear, love, aversion, danger, anger—all have their vocal symbols, many of which through years of

research the writer has become familiar with in several different simian and anthropoidal species. But as the animal brain is less and less complex, as we descend the scale, the reactions likewise become less and less complex, and the expression thereof becomes more and more primitive. Nature does not equip an animal with a faculty in a highly developed form unless it has a need for it in proportion to its complexity.

This brings us to one of the most interesting phases of the study of comparative intelligence of animals, and that is the *gnathic index*. In general the development of the chin of an animal is an index of the mental horizon of his genus. In the higher type of animals, such as man, the complexity of his being allows wide field of individual differences which are not possible in the lower and simpler forms. In the cranial types it is obvious that the human skull is more spherical and the face more nearly vertical than is the case with any other animal. The skull of the ape is more elongated and prognathic, and the facial plane is at a greater angle from the vertical.

In the scheme of nature there appears to be a fixed law of cranial projection, which coincides with other laws of anatomy and intelligence as indicated in the several scales above described. The cranio-facial angle in man, ABC (Fig. 2), is a right angle, and the gnathic angle ADE is approximately the same. The line FG represents the axis of the facial plane, and

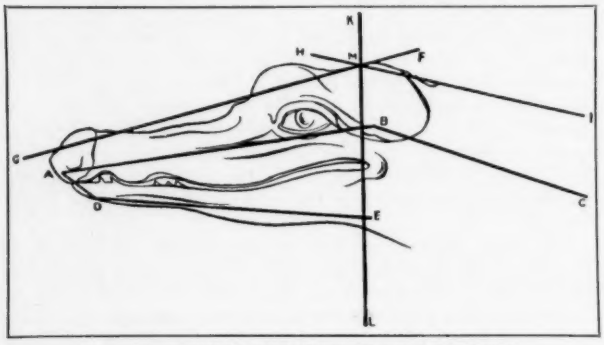



FIG. 5. CRANIAL PROJECTION OF A REPTILE

the line HI is the cervical axis. Reckoned from the vertical line KL it will be seen that the angles formed by the facial axis FG and the cervical axis HI are about the same on opposite sides of the vertical line KL. It will be observed that these lines and angles are those of man whose posture is upright. In Fig. 3, which represents the chimpanzee, it will be seen that both the facial axis FG and the cervical axis HI form greater angles from the vertical line than in man. It will also be seen that the cranio-facial angle ABC is increased by about one-half the angle of the facial axis GML. The gnathic angle ADE is increased in about the same degree.

Fig. 4 illustrates the lines and angles of monkeys in which the angles are widened in a degree measured by the tendency of the animal to assume a horizontal posture like that of true quadrupeds. In Fig. 5 is reproduced a model of reptilian forms of life to which the cranial projection of practically all the remaining orders conforms in principle. The facial axis FG and the cervical axis HI are almost horizontal. The cranio-facial and gnathic angles have been correspondingly widened, and upon a comparison of genera it will be found that this angle widens in proportion to the place of each particular genus in the scale as indicated.

Concurrent with these variations, the longitudinal, transverse and vertical axes of the brain also change their proportion in like degree in accordance with the animalian life and mind as outlined in the chart, Fig. 6. From the lowest animal forms which possess brains of the most rudimentary sort, some of them little more than ganglionic centers, we find infinite gradations of type as we ascend the scale of animal forms, and all in exact coordination of parts. The lower brains are long and narrow in shape. Reptilian brains are approximately four times as long as they are wide or high. That is to say their axes measure about 4 to 1; the *pachyderms* measure about 3 to 1; the *ungulates* about 3 to 1; the *carnivors* about 2½ (or 3) to 1; the *lemurs* about 2½ to 1; monkeys about 2 to 1; apes about 1½ to 1; and human beings about 1 to 1. Thus ascending the scale we find that the higher the stage of development the shorter becomes the longitudinal axis of the brain in proportion to the vertical and the transverse axes. The hemispherical type of brain becomes more and more pronounced, the details better defined, terminating in the marvelous complex brain of man himself. In other words, the cephalic model undergoes a steady metamorphosis, growing shorter and higher as its length diminishes with higher development. The measurements of the human brain average about 1,400 cubic centimeters; that of archaic man, about 1,000 cubic centimeters; and that of the ape brain about 600 cubic centimeters.

It appears that in one or two respects nature exacts a penalty for progress. With the development of reason, the instincts appear to fade. Man has lost his instincts to such an extent that they are no longer reliable guides to action. The apes have likewise forfeited a large portion of this animal inheritance, about in proportion to the substitution of the reasoning faculties. But the lower forms have the main, if not all, activities of existence guided by instinct alone. The very lowest forms of animal life possess certain qualities which seem to disappear as we ascend the scale. In those orders of life where fission is the manner of reproduction the organism has the power within itself of self-restoration, of reproducing members or parts of its body that have been destroyed. Pseudopods restore themselves; when a limb is severed another grows in its place. But as the forms of life become more and more intricate in structure, the organs become more and more specialized, and their power of recuperation becomes more restricted, until in mammalian forms, and especially those of the higher levels of life, the individual cannot even restore or grow a digit that has been severed.

Investigation along the above and similar lines might be followed *ad infinitum*, correlating the various aspects of comparative anatomy and their arrangement in a fashion concurrent with the evolutionary scale, which in turn coincides with the scale of comparative intelligence in animal forms presented herewith; but it is obviously impossible in the space here allotted to present all the data available.

The cordination is apparent and it is possible to employ it in a material way in research. *Given the gnathic angle, or the ratio of the cerebral axes, or the angle of the glottic plane with the larynx, or the number of digit movements, or the vocal range, or the number and qualities of items in the dietary of an animal form, and from any one of these indices it is possible to determine the others with fair accuracy and thereby assign any animal to its place in the scale of nature, physically and mentally.*

The foregoing glances over the various fields of anatomy, physiology and psychics are but general views of their broad panoramas, but they are sufficient to show the principles which govern the development of nature's types. They serve to demonstrate further the psychic unity of all animal life, and to vanquish man's foolish arrogance in according himself exclusive rights to all mental processes above those that are automatic or instinctive. The facts afford ample scientific grounds for believing that the hiatus existing between modern man and the lower extinct types of humanity has been entirely filled during the progress of the race from that low stage to the present one. Likewise, in view of the multitude of data in support of the Darwinian theory, and supplemented by the above coordinations, the same conclusions hold good of the hiatus between archaic man and the anthropoid apes and of that between the latter and the majority of lower animals. The scale shown here is not put forward as an exact measure; nor does it prove capable of containing

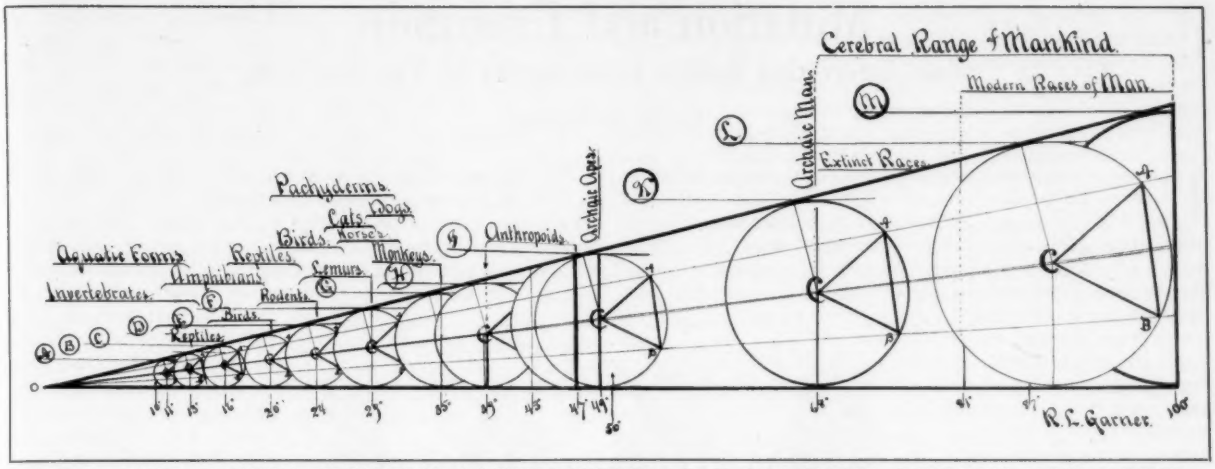



FIG. 6. CHART OF ANIMAL INTELLIGENCE IN WHICH LETTERS *A* TO *M* ARE TANGENTS OR HORIZONS OF THE SPHERES OF MIND AND CONCOMITANT FACULTIES

all forms of life in their endless variation. It is merely an indication of the principles at work in the development of vitalized matter through the ages, manifested in the comparison of animal types. Not all specimens or species conform to this relationship because of variations due to causes distinct in themselves predominating. But from the whole scale of comparative animal life the deduction is clear that every order, family, genus and species of animal lives within a sphere of life, or cosmos, all its own. And these correctly arranged fit into a perspective the outlines of which are tangents to the circumference of every one of these spheres of lief, from zero to its foreplane, occupied by the grand cosmos of man himself as the monarch of animalia.

Nature has its freaks which do not coincide with the general scheme, just as there are discrepancies in the mighty mechanism of the solar system. Science discovers anomalies in every field of research, but it does not abandon a principle because of them. The imbricating circles of animal life, the unity of plan and purpose, the inherent relationship of types, the foetal history of forms, the possession in common of the gifts of nature, stand out as cogent facts with stereopticon clearness in proof of the unity and continuity of design in the realm of vitalized matter. Mind is essentially one in kind, from the acme of human attainment to the protozoa; and it is as universal as the vital phenomena which we call life.

## THE USE OF AUTO-SERUMS IN THE ART OF HEALING

ONE of the newest methods of treating certain infectious maladies is by means of a serum taken from the body of the patient himself. Two different processes are employed in this method, which is technically known as auto-serotherapy.

The first method was devised by Dr. Gilbert of Geneva for employment in cases of sero-fibronous-pleurisy of slow development. The operation consists in extracting by means of a puncture a small quantity, only a few cubic centimeters, of the liquid discharged, and then injecting this beneath the skin of the patient. In about half of the cases thus treated the development of the disease was suddenly accelerated and recovery was comparatively prompt. It must be noticed, however, that this effect is not produced, or but rarely, when the injection is made during the period while the pleurisy is augmenting. The explanation of this remains rather obscure. P. Courmont is of the opinion that when the pleural liquid has been maintained at its maximum level for several days the anti-toxins balance the toxins and that the absorption of the discharge is not definitely begun until the anti-toxins are in the ascendency, so that as a result the *vaccination* is complete. But since this vaccination is sometimes very slow in establishing itself it may be of advantage to hasten it either mechanically by a simple explorative puncture or else by auto-serotherapy. Other authorities suppose that the injection simply releases a diaphylactic reaction which modifies the colloidal state of the liquid so as to facilitate its absorption.

In the second process it is the serum of the blood of the patient which is employed instead of the discharged liquid. Widal, Abrami and Brissaud have shown that it is possible to obtain by this means very valuable results in case of certain infections; it was thereupon employed in serious broncho-pulmonary affections and in cases of grippe. The patient is bled and the serum is allowed to settle in a sterile place and the serum was then reinjected under the skin or into the veins. The intravenous injection is frequently followed by violent reactions on the patient's part (shivering, advance of temperature, curious thoughts of ill-feeling, etc.), and sometimes, indeed, by anaphylactic accidents; but after this the temperature falls and there is a general improvement in the condition of the patient, which may be definitive. The effects just mentioned are those which are invariably observed when foreign bodies are introduced into the circulation, whether directly or indirectly, such as peptone, sugar, colloidal metals, horse serum, emotions of bacilli, etc. But the serum of the patient has itself become the cause of the necessary manipulation of the blood, a foreign body, and this fact forms the explanation of the reaction and the therapeutic results described above. However, this process involves so many difficulties of technique in order to avoid the contamination of the serum that it is but rarely employed, it being considered preferable either to make an immediate injection of the blood of the patient, as is done by Artaud de Vevey or else to inject the citrated blood or plasma of the convalescent according to the methods followed by Grigaut and Moutier.

## A BIRD THAT BUILDS AN INCUBATOR

A REMARKABLE example of a sort of artificial incubation is found, according to a writer in the *Naturw. Umschau v. Chem.-Ztg.* (Berlin) for November, 1920, in the brush turkey (*Talegallas*) which is a native of Australia and New Zealand. This bird prepares a sort of incubator for its eggs which relieves it of much of the labor of brooding over them, which other fowls find necessary. It scrapes together with its strong, muscular feet a great mass or mound of withered leaves and decaying vegetation in which the female lays her eggs, arranging them in a neat circle. The decomposing vegetation soon begins to produce the needful warmth for developing the eggs. Meanwhile the male bird visits this great compost heap from time to time to regulate the temperature, and when the time for hatching comes to assist the young birds in extricating themselves from the decaying mass in which the eggs are reposing. He does not permit his youngsters to leave their warm home, however, until they are fully fledged.

# Mutation and Evolution*

## Some Interesting Recent Experiments by Van der Wolk

By R. H. France

IT must be admitted that the doctrine of evolution no longer awakes the burning interest which it did some fifty or a hundred years ago. It now divides human interest with many other fields of knowledge—perhaps indeed with all of them. At a time when electricity was not a matter of common knowledge to every peasant boy through the electric light and the dynamo, but was familiar only in physical laboratories through a few chosen experiments which now-a-days appear to be not only simple but even childish in nature, many people found not only physical but spiritual thrills even for a life time in its phenomena, as one may read in the Memoirs of the Duke of Lauzun. Before the day when every neurologist became capable of exercising hypnosis, but when Mesmer alone professed to evoke "magnetic sleep," all Europe hung breathless upon this strange affair as upon the founding of a new religion.

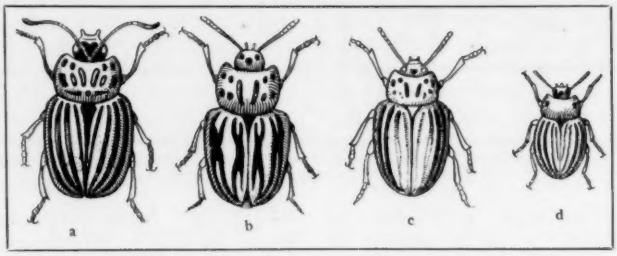



FIG. 1. MUTATION OF THE COLORADO POTATO BUG (*LEPTINOTARSA DECEMLINIATA*)

The type shown at *a*; *b*, *c*, *d* show varieties produced experimentally, but which also make their appearance among local native species and become stable under certain conditions, through heredity. (After Tower.) About 2½ diameters.

Taken by and large mankind is both ungrateful and short sighted. It turns with burning zeal to those matters which it does not understand and loses interest in them as soon as they are explicable and useful. Being in a certain measure disenchanted they remark languidly, "Oh, that's easy to explain like this," etc.

The same thing has happened to the theory of evolution; when Haeckel and Huxley, following in the hesitant steps of Darwin, laid down its laws in bold clear lines, it was an event of European importance. And yet at that time their opinions concerning it were of as hypothetical a character as ours today concerning the canals of Mars. More than fifty years have passed since that time and today everything definitely known and worthy of belief in regard to the theory of evolution has again become a mere "technical matter"; the "fight over Darwin" is stilled, at any rate, so far as the public is concerned. In its place there has come to the fore during the last decade or so a "fight about the mutation theory" which, at least, with respect to the great material value which it involves deserves the attention of the general public.

*Translated for the Scientific American Monthly from *Kosmos*, (Stuttgart) for July, 1920.

The concept of mutation, which first made its appearance in 1903 in a work published by the Dutch botanist, Hugo D. Vries, has after some hesitation been pretty generally accepted as furnishing an explanation for the sudden appearance of new and inheritable characteristics in the animal and the plant. The significance of this view resides primarily in the inheritability of such characteristics and neither in the fact that they are peculiarly striking nor in the fact that they are absolutely new. For example, the moss rose constitutes a mutation which once appeared in a garden and which can be perpetuated both by grafting and by seeds. The merino sheep presents another case of mutation. In 1838 an English ewe gave birth to a lamb having long silky hair, which character was inherited by its progeny. In the same manner the much admired cactus dahlia suddenly made its appearance in Germany, in a plant grown from American seeds.

The divergent races of a certain Colorado potato bug (*Leptinotarsa decemlineata*) also represent mutation; these were first obtained experimentally by Tower and then were discovered in nature; their characters which are pictured in Fig. 1, are inheritable.

Mutations have been found in every group of the plant and animal kingdoms from the bacteria to the domestic animal, and this vast material enables us to gain a certain insight into the laws which govern their appearance. Such mutations occur with especial frequency in years which are unusual with respect to climatic conditions; a second exciting cause is recognized in the transplantation of an organism into a new environment, the most famous example of which is the classic example of all mutations, that of the evening primrose (*Oenothera*) which was discovered by De Vries growing wild in a locality near Amsterdam. A third group consists of cases found among plants and animals subjected to domestication, and a fourth among those unhappy guinea pigs used for experiments, who often exhibit sudden alterations.

From this alone it is possible to deduce a certain conclusion; to employ the terms which best express our modern perception of the nature of life these mutations make

FIG. 2. AN ORDINARY MAPLE LEAF AND *ON THE RIGHT* ALTERED FORM OF WHITE MAPLE LEAF

FIG. 3. GREEN TWIG WHOSE TIP HAS BEEN ARTIFICIALLY INFECTED



FIG. 4. HYBRID PRODUCED BY CROSSING ORDINARY MAPLE LEAF WITH DISINFECTED WHITE MAPLE

their appearance as "responsive reactions." In other words they represent the responses given by the plant to certain definite and extraordinary alterations in environment differing from the usual adaptation to environment only in the fact that they have become definitely fixed and are, therefore, transmitted from parents to offspring. The Vienna biologist, Paul Kammerer, a very successful investigator in this field, expresses this fact in the following neat sentence: *"Mutations are acquired hereditary characters."*

De Vries makes the statement that mutations are due to internal causes which he expresses in the following manner: "Shocks to the molecular structure of the germ plasm"—this, however, is a mere description and, moreover, a description of a purely hypothetical occurrence. Just here lay the weak point of the entire doctrine of mutation. The mutation appeared to be merely a violent mingling of character already present in the plant and the supporters of this theory had no conclusive answer to the objection that all mutations might possibly be merely the hybrids of parents and progenitors unknown to us.

At this juncture of the question Mr. P. C. Van der Wolk published (in *Cultura*, 1919), some noteworthy observations on the study based upon the investigations of nine years.

An ordinary maple shown in Fig. 2 was pruned in the autumn, whereupon in many places the marks of the pruning shears exhibited the appearance of rot. In the neighborhood of these points the tree sent out shoots bearing leaves not only different in form but in color, the latter being white while the former suggested the *Lanciniatus* form of the gardeners. These sprouts bore blossoms and these flowers differed from the ordinary bi-sexual flowers of the maple by being mono-sexual. Here then we have a case of a classic variation by saltation or "jumping" without any transition process; furthermore, this modification contrary to the usual rule proved to be permanent. In short we have here a case of a new kind of maple produced by a sudden mutation. It occurred to Van der Wolk that this apparition of a new form might be connected with the rottenness affecting the wounds received from the pruning shears. He therefore made a bacteriological examination of these injuries and succeeded in isolating a certain bacillus therein. When normal green boughs were inoculated with this micro-organism they put forth white leaves. Thus we have an instance of an artificial production of an alteration of color, as shown in Fig. 3. When normal seeds were planted in ground which had been inoculated with these same organisms they produced plants of altered character. Here then we have at hand a simple means of producing mutation by means of bacterial inoculation and this obviously constitutes a vital stage of progress in the doctrine. Moreover, the supporters of this view will rejoice at a further proof that the vital phenomena of plants may be regarded as a logical series of reactions.

Van der Wolk recalled an observation to the effect that plants which are attacked by fungi produce an increased amount of calcium oxalate, succeeding thereby in killing the parasite. He proceeded to inoculate young maple boughs with calcium oxalate without obtaining any result in the first instance except that the cell sap of the branches thus treated was no longer susceptible of forming bacterial cultures. The inoculation appeared to kill the bacteria. But it was a remarkable fact that when the progeny of white-leaved plants which had been thus disinfected was crossed with normal green-leaved plants the result was the appearance of *spotted hybrids* (Fig. 4) whereas when the white and green plants were crossed without the previous disinfection of the former the offspring always consisted of *white plants only.*

In Van der Wolk's opinion these results indicate with absolute certainty that the doctrine of mutation is no longer in danger of being overthrown by the theory of hybridization. If these experiments are repeated, varied, tested, and confirmed, still more important conclusions may be drawn from them.

Mutations may finally be regarded therefore as the response made by the organism to a disturbance of the harmonious development of the life process, and thus fall into the vast domain of *adaptations*, especially of heritable adaptations.

It would thus appear that one of the most violently debated questions in the doctrine of evolution, *i.e., the inheritance of acquired characteristics*, upon which is based the entire recent view concerning the phenomena of life, is here decided experimentally. And this is a far weightier matter than the phenomenon of mutation itself, interesting as the latter undoubtedly is.

For if it be true that acquired characteristics can be inherited, then every thing that the organism is now or may become is the heritage of experience and the work of its progenitors, and this furnishes us with a key wherewith we may unlock the thousandfold chambers of the evolution of the organic world.

And this first fruitful piece of work along the path of an *experimental doctrine of evolution* justifies us in hoping for the final success of the belief that *adaptation is the product of work done and of that eternal logical connection between cause and effect which rules the universe.*

For the first time man is able not merely to form a theoretic concept of the creation of life, but beholds the law governing that creation. And he would not be the self-seeking creature he is and must be to support his position between the upper and nether millstones of existence did he not at once begin to dream that through his knowledge he may become the lord of this law.

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## PHYSIOLOGY OF THE APPLE

THE trees used in the study were from a 7-year-old orchard on sandy soil near Exeter, N. H., of the Golden Ball variety. Two trees were taken for analysis, the analyses being separately made in each case. Samples for analysis were collected (1) during dormancy; (2) at the awakening of vegetation; (3) when in bloom; (4) as soon as active growth ceased, and (5) at leaf fall. During the dormant period the roots contain more starch than the trunk and limbs, the limbs contain least, but during the budding season the branches contain most. During the 4th period the trunk contains relatively more starch than the roots or branches, and at the 5th the roots again contain more. Sucrose is present in all parts of the tree at all times. During dormancy it is most abundant in the small roots; then follow in decreasing order, 1-year-old branches, then 3-, 4-, 2- and 5-year-old branches. At the budding period the 1-year-old branches are relatively much richer, while the roots have lost heavily, the older branches are slightly poorer. At blossoming time and at the close of growth the roots are richer. The changes in sucrose content of the different parts of the tree are very largely independent of the starch. It is concluded that sucrose is primarily a reserve food material and not simply an intermediate stage in starch hydrolysis. At the beginning of vegetation reducing sugar is formed, at the expense of sucrose, the hydrolysis being more marked in the small roots. The reducing sugars accumulated in the small roots are translocated to the growing parts prior to blossoming, when they are utilized in tissue formation. Reducing sugar appears to be the main migration form of the carbohydrates. Fats are always present in the apple and apparently function as reserve food material since they disappear from the roots during the early stages of growth and accumulate in the 1- and 2-year-old branches. The nitrogen reserve materials are stored mainly in the younger branches from which they pass to the actively growing regions upon the awakening of vegetation. The phosphorus required in building new tissues at the awakening of vegetation is mainly obtained from the younger branches, while the translocation of potassium occurs mainly from older parts than those that supply the needed phosphorus and nitrogen.—Abstracted through *Chemical Abstracts* from *Tech. Bull.* 13 (1920). of New Hampshire Agr. Expt. Sta.

THE MOUTH OF THE FRITTON DECOY FOR TRAPPING WATER FOWL

# The Fritton Decoy

## A Curious Method of Snaring Game

THE section of England known as Norfolk Broads is a highly interesting one and is a great vacation center in summer. A triangle, having the coast for its base, Lowestoft at the left, and Palling at the right angle, with Norwich at its apex, will contain nearly the whole of the Broad district with its 5,000 acres of lakes and broads, and 250 miles of navigable rivers. In these, say, 250 square miles may be found during a holiday trip delightful occupation for seekers of "fresh scenes and pastures new." For the angler such sport awaits him as he cannot obtain elsewhere as the takes of fish at certain times and places are simply extraordinary, especially of the coarser kinds of fish, such as bream, pike, etc. He may choose for his fishing ground water either deep or fleet, running or still, clear or obscured, with the assurance that he will not go away either empty-handed or disappointed.

An interesting excursion may be made from Lowestoft to what is known as Fritton Lake or Fritton Decoy, where the snaring of wild fowl is carried on by a contrivance peculiar to these and other nearby waters, so that an explanation of these decoys may prove of interest.

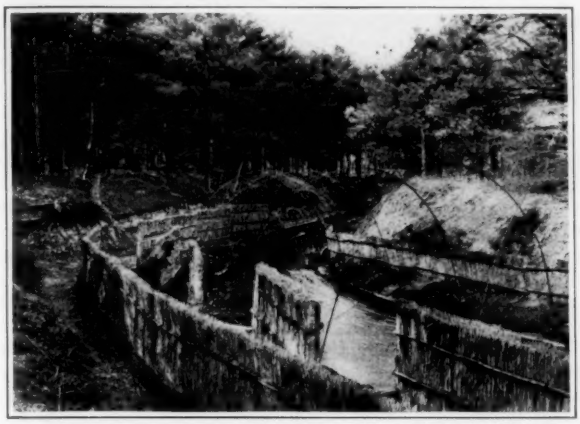
Mr. G. Christopher Davies, an authority on the Norfolk Broads and Rivers, writes of Fritton Decoy as follows:

When with the approach of winter the wild fowl come to us from northern latitudes they find but little of that quiet and seclusion which are necessary to their abiding with us in any great numbers. The protuberance of Norfolk and Suffolk into the North Sea arrests a large number of the southward-speeding birds, and the great lagoons, silent rivers, and far-stretching marshes of East Anglia offer them a safer harborage than do other parts of England. Yet the proportion of fowl remaining even in so suitable a district is not by any means so large as formerly. Of course there are many reasons for this: marshes are drained and lakes lose their wildness, the number of sportsmen is greatly increased, and no spot is long free in the winter time from the noise of guns. The chief cause, however, in our opinion, is the decadence and disuse of decoys; and this view is shared by most of the 'water-abiders' among the Broads.

One night, while out on a certain quest on the river Bure, near Ranworth, in the midst of the best possible grounds, or waters rather, for wild fowl, we were struck by the scarcity of ducks going to and fro at night and morning 'flight' time: and on remarking this to the eel-fisher who was with us, he said, "Oh, it was a bad job the giving up of Ranwórth decoy. When that was worked there was plenty of fowl for the decoy and plenty for the flight-shooters, but since the decoy was given up and the Broad shot over, the ducks don't come and nobody gets any."

The reason of this is obvious when the habits of ducks are considered. They feed chiefly by night, when, in the cover and silence of the darkness, they fly to different feeding grounds which they dare not visit in the daytime. Just before dawn they fly back in small bodies to some sequestered lake where the argus eyes of numbers collected together afford a feeling of security to the timid fowl. If they are not disturbed in their retreat they spend the daylight there, feeding a little, sleeping a little, and preening themselves until the night gives them leave to go forth in fancied safety. It is while they are thus collected in numbers that they fall victims to the decoy. So silently and skilfully, however, is the decoying practised that while half a hundred ducks are having their necks wrung by the decoy man within fifty yards of the water's edge, hundreds more may be sitting on the water close by all unconscious of the tragedy which is being enacted.

No phase of the pursuit of wild creatures by man for food or profit is more interesting than the system of decoying wild fowl, as practised for generations in East Anglia. Wild-fowl decoys have decreased sadly in number during the last generation; yet in these days of depressed agriculture, it is surprising that gentlemen who have the opportunities of suitable



A CURVE IN THE DECOY SHOWING THE OBLIQUE SCREENS

possessions do not embark in what is really a profitable pursuit. A small wild-fowl decoy would pay better than a small farm nowadays, and at a smaller expenditure of capital and labor.

Much of the mystery which formerly surrounded the working of decoys has been dispelled by the patient investigations of Mr. Thomas Southwell, F.Z.S., who has gone into the subject with loving zeal and made his discoveries public. It is to him that the writer owes the pleasure of seeing a decoy worked.

Fritton Lake is not, strictly speaking, a "Broad," as it is not connected with or a broadening of any river. It is also out of the marsh district, in a sylvan part about three miles from the coast, and midway between Yarmouth and Lowestoft, and is really a deep lake, about three miles long and a sixth of a mile wide, of a straggling and irregular shape, lying between wooded banks of great beauty, and with numerous creeks or indentations of which advantage has been taken to construct the decoys. There are two groups of decoys, one at each end of the lake, and those we saw worked are at the east end, and are the property of Sir Saville Crossley. A decoy should be sheltered from all observation of passers-by on roads or fields; but owing to gaps caused by the falling of large numbers of trees in a great gale we could catch glimpses from the highroad of the water in the secluded bay where the decoys lay. Two or three score of ducks were swimming quietly about, and the keeper told us that men driving by would, out of sheer wantonness, crack their whips or shout for the purpose of putting the fowl to flight. He had built up huge bastions of reeds in the spaces left by the recumbent trees to screen the decoy; but the damage caused by the gale was not so easily set right, and the fowl were much shyer than before. Decoys are worked, if fowl are plentiful, twice a day—morning and evening. The weather in which the most ducks came was snowy, cold weather, when the ground was covered with snow, and food hard to get at, yet when the frost was not severe enough to "lay" the larger pools. At the time of our visit the decoy had not been worked for a few days, and some fowl were present, but very shy, as some one had been passing up wind of them, and the keeper had seen a footmark in the wood which was not his own. Cautioning us to stoop as low as he did, not to cough or sneeze, or speak above a whisper, or tread on a dry branch, the keeper gave us a bit of smouldering turf, the object of which is to destroy the human scent, which would otherwise travel down wind and alarm the ducks.

Like all other birds, ducks like to swim or rise with the wind in their faces; hence it is only possible to work those pipes which are to windward of the birds, and in all decoys there are pipes made to suit the prevailing winds.

The decoy-dog accompanied us, and was a retriever of reddish color, red being apparently a color which more powerfully excites the curiosity of the ducks than any other. This dog was a large one—too large, the man said, inasmuch as small dogs were found to be more effective. As we approached the lake we entered a dry ditch, with a bank thrown up on the side next the water. This was the "traverse," or means of approach to the decoy; and along a series of these traverses we proceeded crouching double, hats off, the peat-smoke making our eyes water, and the dog tripping us up. There was something decidedly conspirator-like in this stealthy progress over the soft dead leaves in the narrow ditch, and under the deep gloom of the trees and bushes which shaded the earthworks; and our expectations were wound up to a high pitch, our eagerness being, however, checked by our guide, who, in hoarse whispers, bade us "keep lower, keep lower."

In order that the reader may understand the subsequent proceedings we will leave ourselves crouching breathlessly behind the reed screens while we explain what an after-inspection, when there were no ducks present, revealed of the plan of a decoy. Out of the quiet wood-surrounded bay, dykes, or arms of water, extend into the land. Each dyke is about 18 feet wide at the mouth, and gradually narrows to a point, curving the while to the right, or with the sun for about the quarter of a circle, and is 80 or 90 yards along the curve. Over this dyke are light arches, sometimes made of long pliant rods and sometimes of iron. These, again, are covered partly with cord network and partly with galvanized wire netting, the network being generally near the mouth, where it is more invisible than the wire, and the wire netting over the rest. These avenues of netting are called "pipes," and are, speaking roughly, 10 feet at the open end, diminishing rapidly to 3 feet in diameter. At the small end is a pair of double posts

THE END OF DECOY PIPE WHERE FOWL ARE CAUGHT

in the groove between which slips the first hoop of the "tunnel net," which is a bow-net 8 or 10 feet long, the extreme end of which is stretched out and tied to a stake. Owing to the curve of the pipe, the ducks in the decoy can only see a short way up it, and the massacre of their comrades and the move-

ments of the decoy-man are unseen by them. Along the outer curve of the pipe, for a distance of nearly half its length from the mouth, screens made of reeds are placed obliquely, overlapping each other, and about a yard apart, the openings looking up the pipe; while toward the lake they present an impenetrable front. Continuous screens along the edge of the lake near the pipe and outside the pipe and oblique screens still further add to the secrecy.

Inside the pipe is a wire-work pen, in which is immured a lively quacking duck. The water in front of the pipe and inside is kept free from weeds, and is very shallow, with, if possible, a hard bottom, so that the "feed" with which the decoy is plentifully supplied may be easily seen and got at by the fowl. The oblique screens are connected by low barriers called dog jumps. Through two or three of the screens flat sticks of wood are inserted edgewise. If these are turned flatwise, they form small openings or peep-holes, through one of which the keeper has been peering while we wait.

Blowing his turf to fan the smoldering fire, he beckoned us on, but with emphatic gesticulations to keep low. He planted each of us at an eye-hole, and then we saw a very beautiful and interesting sight. Quite at the mouth of the pipe was a flock of teal paddling quietly about, some with their heads tucked back, fast asleep, and others toppling over, feeding on the grains which had sunk to the bottom; but the greater number just floating lazily, with the sun shining on their glossy blue and chestnut heads. It was indeed a curious sight to see these wild and timid little creatures within a few yards of us, all unconscious of the presence of three men intent on their capture. We held our breaths for fear of disturbing the intense stillness which reigned around—a stillness so great that the cry of a distant jay caused the ducks to lift their heads in listening attention. Beyond the flock of teal were several decoy ducks—tame ducks of a color and marking as nearly as possible like the mallard. These decoy ducks are kept in the decoy, and trained to come in for food whenever they see the decoy dog, or hear a low whistle from the decoy-man. Beyond the decoy ducks was a flock of mallards, looking large and sitting high on the water compared with the teal.

Then the obedient decoy dog jumped over one of the jumps on to the narrow strip of margin within the pipe, and so became visible to the fowl, returning to his master over the next one. In an instant every head was up among the teal, and with outstretched necks they swam toward the dog, their bright eyes twinkling, and every movement indicating a pleased curiosity. They halted as the dog disappeared; but as, at a sign from the keeper, he jumped into the pipe again higher up, the birds again eagerly followed him. They were now well within the pipe and directly under my nose. The keeper ran silently toward the mouth of the pipe so as to get behind them, and then appearing at one of the openings between the screens, he waved his handkerchief—a motion invisible to the ducks still outside the pipe, but a terrifying sight to those within. In an instant they rose and flew up the pipe in a panic, the man following them up and waving his handkerchief at each opening. As the pipe grew narrower, the doomed birds struggled along, half flying, half running. Only one dared to turn back and fly out of the pipe, regaining safety by its boldness. The others crowded through into the tunnel net, and when all were in, the keeper detached the first hoop from the grooves, gave it a twist and so secured the ducks.

Except to work the decoy, the keeper never approached it in the daytime, all necessary work being done after the "rising of the decoy," that is, after the fowl had left on their nightly excursions. In hard weather, when the ice formed during the night, it had to be broken in the early morning before the ducks returned, as, unless the pipes and a space of water in front of them were kept open, the decoy could not be worked.

We learn that about six decoys are now worked either regularly or occasionally in Norfolk. The present rage for shooting will go far toward exterminating the decoys, and landlords who feel the pinch of tenantless farms, will let the shooting of places which for generations have not been disturbed by the sportsman's gun. We find that at the decoy now being described the average take of fowl each season is 1,000. This last winter, however, it was very small, as, on a visit there in the spring, the keeper said that only about 250 fowl had been taken—less than a day's work in more prosperous times.

In a shed at the keeper's cottage the fowl were laid out and counted—21 to our computation, 11½ to the keeper's; the reason being that teal and widgeon are only accounted as "half-fowl," and two go to one mallard, or twenty-four to the dozen.

Our next visit to Fritton was in the following spring for the purpose of photographing the salient points of the decoys, and we were favored with a still, bright day. We first visited the decoys at the Fritton end of the lake, and the views of the screens and the interior of the pipes are of these decoys. The view, representing the end of the pipe and the tunnel net, is the one which we had seen worked in the winter. Altogether we obtained sixteen negatives, all of them good and typical, and a set as unique as in a few years' time they will be valuable. The lake was then merry with Easter Monday holiday parties, and picnics were held at the very mouth of the pipes. The decoy ducks were still swimming about the decoy, and we found some of their nests among the rough herbage and brushwood behind the pipes. A curious fact in connection with these nests was, that the birds on leaving them covered the eggs over with dead leaves so as to hide them. This is an interesting bit of evidence in favor of reason rather than instinct, for these were domestic ducks leading a semi-wild life and taking the precautions observed by wild-fowl.

## DIFFERENCE BETWEEN MOLDS AND WOOD DESTROYERS

NOT all fungi which live upon wood impair its strength, but conditions which promote the growth of molds, blue-stain fungus, and other non-injurious fungi are usually favorable to the growth of the wood destroyers, and these may be active on the same wood bearing the molds. Hence, the presence of mold on timbers intended for any structural purpose should cause them to be looked on with suspicion.

In the early stages of their growth the molds and the wood-destroying fungi sometimes have a very similar appearance, and there is no simple means known to the U. S. Forest Product Laboratory by which lumbermen and wood users can separate them at sight. The surface growth of molds is generally cottony or felty in appearance; the mycelium or fine mold threads are interwoven, never compacted into membranous sheets or strands. The mycelium of wood destroyers may be fluffy and glistening, but more usually are compacted into strands or fan-shaped patches.

The characteristic feature of mold growth on wood is the fact that the minute threads which enter the wood do not bore into the wood fibers or dissolve them away. They pass through the spaces between the fibers or enter them through the natural openings, called pits, which are found in the walls of certain cells. Starches, sugars, and other contents of wood cells constitute the food of the molds.

The wood-destroying fungi are able to send their threads right through the wood fibers, breaking down the cell walls and utilizing portions of this decomposed material as food. This action very markedly weakens the wood, making it crumbly, stringy, or spongy—in other words, producing rot or decay. The presence of wood-destroying fungi in an advanced stage of growth is evidenced by fruiting bodies, commonly called mushrooms, toadstools, conchs, or brackets.

The principal economic loss caused by molds is through the staining or discoloration of the wood. No greater injury may be caused by the wood destroyers in their early stages; but their work will continue and finally result in the destruction of the wood if favorable moisture and temperature conditions prevail.

# The Alternation of Generations

## A General Law Governing the Development of Both Plants and Animals

EVERYONE is familiar with certain instances of the phenomenon known as the alternation of generations in living creatures. Few people are aware, however, that this is a general law governing the development of both plants and animals. It was first clearly recognized by Hofmeister in the mosses and the ferns.

As we all know ferns bear no flowers, but the lower surface of their leaves is covered with a fine powder consisting of spores which are borne away by the slightest breath of air. When these spores fall upon suitable earth and at the same time find favorable conditions of heat and humidity, they germinate. But strange to say the resulting plant is not a fern! From the spore there first sprouts a short green filament, whose end expands and spreads out upon the ground so as to form a green cordiform blade having a diameter of barely a centimeter. This is the "thallus" (sometimes called prothallus). These thalla are produced abundantly in the dry earth in which exotic ferns are cultivated, both the surface of the earth and the walls of the flower pot being thickly sown with them. The thallus lives a perfectly independent life, obtaining the mineral salts which it requires from the earth by means of the hairs which serve as absorbents as well as fixators of the plant, and at the same time building the carbohydrates of which it has need from the carbon-dioxide in the air by means of the chlorophyll in its own cells.

The thallus is, as a matter of fact, a plant with a definite individuality; it is capable of reproducing itself by means of cuttings; it is generally very ephemeral in character and, finally, it forms no spores; hence we see that it is an organism which is very different in nature from the fern which gave it birth.

In the adult state the thallus forms sexual organs which produce sexual cells or "gametes." As in most plants and animals the female gametes are comparatively large and each one is contained in a sort of bottle with a neck. The male gametes are much more numerous and are very mobile. In due time the latter perform their proper functions of fecundating the former.

Starting with this typical example Mr. L. Maltruchot, a French savant, contributes a most valuable article on the subject to the April (1920) number of the well-known scientific magazine *Scientia* (Milan).

Speaking of this particular case, the author remarks:

"The fecundation here consists in a fusion of the two kinds of cells, protoplasm with protoplasm and nucleus with nucleus, in such sort that the product of the fecundation is a single cell, the 'egg,' which becomes the point of departure of a new development. Lodged in the mass of the thallus from which it derives its nourishment the egg increases in size, undergoes the process of division and in this manner develops so as rapidly to form an embryo, in which it is soon possible to discern a little root, a first leaf, and a bud. It is, in fact, a miniature fern which will gradually increase in size until it has become a large and leafy fern capable of producing spores.

"When first formed the young fern is fed from the thallus but later it abandons its parasitic life and acquires an independent life thanks to its root and the chlorophyll of its first leaves. Meanwhile the mother thallus, exhausted by the growth of the little fern, withers and dies."

Obviously here we have a complete cycle consisting of two phases, the *thallus* which produces gametes, constitutes the gametophyte phase, and the leaf-bearing fern which produces spores and is, therefore, called its sporophyte phase. Between these two phases there is a remarkable antithesis, not only in form, structure, and size, but likewise in origin and in end.

### THE MOSSES

"The same scheme of development is found in the mosses. But here it is the comparatively large plants commonly known as moss, *i.e.*, a greatly developed thallus, comprising an erect axis provided with expansions in the form of leaves and attached to the ground by absorbent hairs with which we are concerned. This 'leafy thallus' is a true gametal type, since it forms gametes of both sexes whose union results in eggs. Each egg attached to the mother plant develops into a sort of erect stem without branches which finally produce spores. This organ, which is called by botanists the 'sporogone' represents, therefore, the sporophyte phase of the moss; it lives indefinitely as a parasite upon the mother plant without ever freeing itself." Thus we see that while the cycle of development is the same in these two groups, in the ferns it is the sporophyte phase which is most important and most greatly differentiated, whereas in the mosses it is the gametophyte phase which is predominant.

Recent researches upon the physiology of cells have led modern botanists to the conclusion that the formation of the egg and the formation of the spore are in a certain sense antagonistic, constituting, as it were, the two poles of the plant's development. Mr. Maltruchot thus discusses these stages:

"The formation of the egg as a result of fecundation consists essentially of the fusion of two gamete-cells. But whatever may be their differences of size or of form these two gametes appear to bring to the union *practically equal quantities* of a substance contained in their nuclei which has been termed *chromatine* because of the affinity it exhibits for coloring matters. This chromatine is borne by the corpuscles in the form of rods known as *chromosomes*, and *two gametes of the same species always contain the same number of chromosomes.*

"As a consequence the nucleus of the egg formed by the union of the nuclei in the two gametes contains twice as many chromosomes as either of the gametes.

"Still another fact has been thoroughly established by cell study, namely, that when a cell divides into two 'daughter-cells, the amount of chromatine in the nucleus is divided equally between the two new nuclei and save for an exception, which we will refer to later, each of these two nucleus-daughters contains the same number of chromosomes as the nucleus of the mother cell, so that all the cells proceeding from the sectioning of the egg will have bivalent nuclei.

"But upon the formation of the spores a new phenomenon makes its appearance; the spores are born four by four from a mother-cell called the tetrad cell. This tetrad cell undergoes two rapid divisions in succession in the course of which the number of chromosomes appear to be reduced to half. If the mother cell possesses eight chromosomes each spore will possess only four.

"We see, therefore, that while at the formation of the egg the number of chromosomes is doubled when the spore is formed the number of chromosomes is reduced and the spore carries with it the 'reduced' number of chromosomes, or rather the 'simple' number of chromosomes.

"This simple number persists in all the divisions which succeed each other, beginning with the germination of the spore and, as a result of this all the cells of the gametophyte possess monovalent nuclei. The same thing is true of the gametes and thus we have come back to our point of departure."

The ingenious theory thus formulated by Hofmeister has been extended, thanks to modern cell study, not only to those plants known as gymnosperns but also to the phanerogams of

flower bearing plants. This governing idea has controlled the study of the embryogeny of the higher plants for more than fifty years, and it is a well established fact in the view of modern botanists that this law of the alternation of generations is operative among the higher plants in the sense that the scheme of development, given above applies to them as well as to the plants of lower organization, such as mosses and ferns.

"But in proportion as we go higher in the series of the flower-bearing plants," remarks our author, "we observe a sort of decadence of the gametophyte. In a lily, for example, or a butter cup, the gametophyte is represented merely by a mass of certain cells in the body of the ovule, or by one or two cells of the grain of pollen. So that we may consider that among the higher plants the entire body of the plant, including root and stem, leaves and flowers, represents the sporophyte phase, the spores to which it gives rise being the so-called 'microspores' which eventually become grains of pollen, and the so-called 'microspores' which remain included in the tissue of the interior of the ovule."

He even adds that the same general law of development holds good in the immense majority of animals, particularly in all those higher animals in which the gametophyte phase is likewise reduced to a few lines of cells which give birth to the sexual elements. Among these also we may consider, therefore, that there exists an alternation of generations, no longer, to be sure, in such a special sense as it exists among the Hydras and Medussas, "but in the general sense which we have defined as a result of our cell study."

He sums the matter up by declaring it as his fixed opinion that the alternation of generations forms a biological law of the most widespread application, governing the development of all the more highly organized living creatures, whether plants or animals.

In the May issue of *Scientia* the author continued the study of alternation in generations as applied particularly to the life cycle in the lower order of plants. The following is a direct quotation of this second article:

STUDIES OF THE LIFE CYCLE IN THE LOWER ORDERS OF PLANTS

"In the first portion of this study we put aside the consideration of the lower orders of living creatures, such as thallophyte plants, protozoan animals, etc. The psychological study of these creatures is far more difficult and more delicate a matter, and it is only very recently that it has been undertaken. But the new idea, which it has revealed are of great importance: They have enabled us not only to perceive the full extent and the universal application of the law of the alternation of generations but also to gain more precise information concerning the phenomena of fecundation (the formation of the egg, on the one hand, and of meiosis (the formation of spores), on the other; and as we have seen these two phases constitute the critical stages of development of all living creatures.

"To begin with the general or universal application of the law has been confirmed. Among the thallophytes (algae and fungi) many cases are known in which the scheme of development is of integral application. The red marine algae, and the ascomycetes fungi (Morillas Pezizas) fall strictly under the general law, *i.e.*, the sporophyte, the product of a normal fecundation lives as a parasite upon the gametophyte; it forms one or more so-called 'fruits' which produce spores; finally, these spores are produced by meiosis to the number of four (or two or eight or sixteen) in mother cells analogous to tetrad cells.

"Thus far we have come across nothing which is not practically normal—and here again as in all the creatures of which we have spoken the two branches or phases of the cycle, although morphologically distinct are not separate. And not only are they contiguous but the *sporophyte phase lives as a parasite upon the gametophyte phase*, just as we have seen was the case in the mosses and, likewise, at least in the beginning, in the ferns and higher plants. Consequently it may be said that in all the creatures with which we have been thus far concerned the gametophyte phase which furnishes nutrition and the sporophyte phase which acts as a parasite are, at least for a certain length of time united with each other so as to form a body which may be considered a unit; this is the rule which governs the case and which has thus far been absolute.

BROWN ALGAE AND MYXOMYCETES FUNGI

"But let us now consider the brown marine algae (Cutleria-Laminaria) and the myxomycetes fungi (Didymia) which form an exception to this rule.

"*Brown Marine Algae.*—The cutleria, attached to the rocks of the shore produce gametes and eggs: these eggs floating freely in the water do not develop on the mother plant. After having wandered for some length of time at the whim of wind and wave, they attach themselves to a rock and germinate forming an embryo which is very different morphologically from a cutleria and which leads an existence entirely independent of the mother plant. But this embryo is a well-known organism which was long ago described by botanists under the name of Aglaozonia. The aglaozonia in their turn are incapable of producing gametes, but produce spores on the contrary, and, furthermore, each of these spores upon germination gives rise to a cutleria thallus. The discovery of this fact makes the matter clear: the cutleria and the aglaozonia are not two different species of algae as was long believed but merely the two phases of the vital cycle of the same plant.

"The same peculiarity is found among the Laminaria. These giants in the world of marine flora produce only spores. These spores produce upon germination not laminaria but microscopic thalla. So small that they long remain unperceived; from these thalla gametes and eggs are born which produce new laminaria.

"*Myxomycetes Fungi.*—The same fundamental development takes place among the myxomycetes fungi but after a very different mode. A didyma lives upon decaying wood; it produces small 'fruits' abundantly filled with spores. Each of these spores gives rise upon germination to a very singular thallas. This thallas is at first a small cell lacking a rigid envelope and consisting, therefore, merely of a bit of naked protoplasm having a nucleus and known as a 'myxamoeba.' This myxamoeba grows and divides into myxamoeba daughters which part company; then these undergo division in their turn and so on indefinitely, so that the thallus of the didyma is a fragmentary and scattered thallus composed of innumerable free and mobile cells all similar to each other. At a given moment some of these cells become gametes and fuse together in couples to form eggs which are likewise naked and mobile. The egg grows in its turn without dividing its mass into fragments but dividing its nucleus repeatedly; it thus forms a 'plasmod' which is transformed later into a spore bearing fruit. The gametophyte formed of *dissociated myxamoebas* preceding from the germination of the spore, and the sporophyte in the form of an *undivided plasmod* produced by the germination of an egg constitute the two phases, entirely independent of each other which compose the cycle of development of a didyma.

THALLOPHYTE PLANTS

"We see, therefore, that the thallophyte plants—and the same thing is true of certain of the lower animals—furnishes us many examples in which the two phases of the development are represented by two entirely separate, *dissociated* organisms leading an existence independent of each other. These organisms which a superficial examination might cause one to classify as two species quite distinct and even belonging to taxinomic groups quite remote from each other, are therefore in reality the two successive and dissociated phases of the same living creature. Indeed it is worth while remarking that it is infinitely probable that among the numerous forms

of the lower plants and animals, many should really be coupled together as being merely the two phases of development of the same creature.

The existence of these plants which develop in dissociated phases such as the cutleria raises an interesting question, namely, whether the forms marked by dissociated development are to be regarded as more primitive than those in which the two phases remain *associated* or whether, on the contrary, they are to be looked upon as derivatives of the latter. In our opinion it may be accepted as a principle that the parasitic life is acquired secondarily, being subsequent to a mode of life which was originally independent. If this is true we are obliged to believe that a cycle of development with a parasitic sporophyte is merely a subsequent adaptation of a cycle of development marked by an independent sporophyte. Accordingly the case of the cutleria and of many other thallophytes appears to represent the original mode of life from which have been derived later the various modes of development of the intermediate plants and the higher plants.

"Another thing supports this idea: In the cutleria, as in many other thallophytes, the gametophyte and the sporophyte appear to be practically equal in importance, not only as regards their respective sizes but with respect to their duration of life and their morphological differentiation. Furthermore, it is very satisfying to the mind to believe that this state of balanced equilibrium between the two phases of the life of the living creature is the original state from which have been derived those cases where there is an enormous disproportion between the two phases.

"Furthermore, from the primitive type having practically equal phases there are derived on the one hand those forms in which the gametophyte is of the most importance (including numerous ascomycetes fungi, red marine algae, hepaticus mosses) and, on the other hand, those forms in which the sporophyte is preponderant (as in certain thallophytes and higher orders of plants). Hence the double phyllum, which in the eyes of evolutionary biologists, embraces the entire world of plants, in spite of their high degree of differentiation.

"At all events, whatever may be thought of these theoretical views the fact remains that among certain of the less highly evolved plants the two phases of the development exhibit, on the one hand, a sort of parity or equivalence which has ceased to exist among the more highly evolved plants, and on the other hand, a reciprocal independence as regards their mode of life, of which it is no longer possible to find a trace in the higher and intermediate plants, or even in many of the lower orders of plants.

### TWO SEXES IN THE THALLI OF FUNGI

"Finally, the study of certain fungi, including the ascomycetes (Pezizas of the genus pyronema, etc.) or Basidiomycetes (Coprins, Uredinea, etc.) has thrown fresh light upon the essential nature of the phenomena of fecundation and of meiosis.

"*The Coprins.*—The Coprins are, as their name indicates, fungi which grow in abundance upon manure; when mature the gills dissolve into a sort of inky fluid and the spores are formed four by four at the expense of the tetrad mother cells, known as 'basids,' which are found in great numbers upon the gills of the lower surface of the fungus.

"But in the Fimicolus or dung-growing coprin, the spores, although similar in appearance are really different in nature, since when they germinate they produce two kinds of filament bearing thalli, which may be designated by the signs plus (+) and (—). These thalli are composed of filaments formed of cells having a single nucleus. A (+) thallus when cultivated alone, even in the most nutritious medium develops abundantly but continues sterile, and the same thing is true of a (—) thallus, but if we form a mixed culture of both kinds either by sowing in the same medium (+) spores and (—) spores or, by mingling (+) thalli with (—) thalli, certain fructifications occur, *i.e.*, we obtain these little fungi on the lower surface of which basids and spores are formed.

"*Sexually Different Thalli.*—From this we are bound to conclude, in accordance with all the teachings of biology that the two kinds of thalli, though so similar in appearance are in reality *sexually different*, and that upon their conjunction there occurs a fecundation which results in the development of the fruit which bears the spores.

"But let us inquire what really takes place in the mixed culture. We observe two cells, one of which belongs to a (+) thallus and the other to a (—) thallus, form a junction by means of anastomosis; their protoplasms become fused together and their nuclei approach each other without becoming fused. This sexual approach of the two nuclei toward each other creates such a bond between them and causes them to be so closely associated in their later evolution, that the name of *conjugated nuclei* or of *dicaryon* has been given to them.

"Bi-nucleated cells thus formed germinate by thrusting forth a filament embracing both nuclei: the latter approach each other, arrange themselves side by side and *undergo division in a parallel and simultaneous manner.* The filament continues to grow and the dicalyon to undergo division in the same manner, and this continues indefinitely until first the fungus cap is formed and then the basids, *i.e.*, the tetrad cells which are the mothers of the spores.

"This action must be interpreted as follows: The fusion of the (+) and (—) cells with the formation of a dicalyon is evidently a process of fecundation and the filaments constituted by the dicalyon cells represent the sporophyte phase. In the egg the two nuclei of different signs, the '*paternal*' and '*material*' as they may be called, remain morphologically distinct in spite of their intimate association in the dicalyon. In the same way the chromotines of paternal and maternal origin continue to remain distinct during the course of the divisions of the egg and the ulterior formation of the sporophytex. Finally, it is in the mother cell of the spores at the very moment when meiosis is about to occur, that the two conjugated nuclei finally becomes fused into a single nucleus and that the paternal and maternal chromotines become intimately mixed.

"The conjunction of two gametes accompanied by a fusion of the protoplasms and a simple approach toward each other without fusion of the nuclei is by no means peculiar to the coprin. The pezizas of the genus pyronena exhibit the same peculiarity bringing into operation highly differentiated sexual organs. And in the animal kingdom itself we may cite the case of the Copepods in which the nuclei are of paternal and maternal origin, remain distinct not only in the fertilized egg but also in the tissues of the embryo which results from a process of division which takes place in the said egg, and doubtless, also up to the very stage in which the chromatic reduction occurs.

### LONG SOUGHT ANSWER TO A MUCH VEXED BIOLOGICAL PROBLEM

"We may, therefore, hold it to be solidly established that the interpretation given above is correct, and if this is true the case of the Basidiomycetes assumes considerable theoretical importance and enables us to explain the question which has hitherto remained highly obscure.

"Up to the present time, in fact, biologists have long debated whether the *apparent* fusion of the nuclei, which is the rule which governs fecundation in plants and in animals, is really an actual fusion involving the intimate mingling of the paternal and maternal chromotines—or whether, on the contrary, the paternal and maternal chromosomes remain distinct until meiosis occurs. The explicit case of the Basidiomycetes given above proves without doubt that the second hypothesis is correct.

"Since this is the truth of the matter, in the case of the Basidiomycetes, we are obliged to assume in default of convincing argument, to the contrary, that the same thing is true among other plants in which the phenomenon is less clearly defined and as it were more condensed.

"We thus arrive at the conclusion that as a general thesis

and among animals as well as among plants the following theory of fertilization is correct:

"1. At the moment of fecundation there is merely a simple approach toward each other of the chromatic rods of the two gametes;

2. In the course of the development of the sporophyte the two chromosomes of a nucleus remain distinct and it is not until meiosis occurs that the intimate mingling of the paternal and maternal chromatines takes place, this being probably accomplished by the fusion in couples of chromosomes of different sex. This latter hypothesis likewise has the merit of furnishing a ready explanation of the numerical reduction which causes the number of chromosomes to be divided in half at the moment of the formation of the spore.

"The question still so hotly debated after the individuality of the chromosomes in the nucleus in a state of rest is answered in the same manner: it is impossible to believe, in fact, that the chromatines of different sex would continue to remain distinct were it not that the rods which bear them retain their individuality during the course of the numerous fluctuations of the life of the nucleus. And if we accept this view of the persistence of individuality in the chromosomes of the sporophytic nuclei, we must undoubtedly accept it as applying also to the nuclei of the gametophyte."

CONCLUSION

The preceding observations have shown how suggestive is the study of the lower order of plants and how valuable are the data which they furnish to natural history. It is by the study of these humble organisms that we have been able to elaborate this great law of the alternation of generations which governs the development of the entire organic world; it is by such study likewise, that it has been given us to procure a profounder knowledge of the phenomena of fecundation and of meiosis; it is to this likewise that we are indebted for the most topical proof of the persistence of the individuality of the chromosomes in the quiescent nucleus. All these results are due to the fact that these modest organisms present in a clearly defined and obvious form an entire series of phenomena, which in other living creatures are susceptible of observation only in a greatly shortened and condensed form which is infinitely less evident to the eye.

## HOW YOUNG PLANTS DEFEND THEMSELVES AGAINST STARVATION

DURING the last few years a great deal of research has been devoted to the powers possessed by men and animals to resist starvation, and the subject has acquired an exceedingly keen interest of late, because of various tragic conditions and circumstances abroad. Strange to say, however, there has hitherto been but little study of a similar phenomenon in plants. Yet since plants form the ultimate food supply of animals it is obviously highly important that the conditions governing their nutrition and their powers of resistance to malnutrition should be known. The well-known French botanist, M. Henri Coupin, has recently, we are glad to say, made a special study of this subject and the results of his observation were laid before the French Academy of Sciences at their session of September 13, 1920.

M. Coupin devoted his attention to seedlings reared in the dark and, therefore, deprived of the carbon of the atmosphere, being unable to assimilate it by means of chlorophyl under these conditions. The only nourishment given the young plants was distilled water. They were allowed to remain after germination in a dark room until they perished, thus affording an opportunity to note the time during which they were able to resist this practical starvation. M. Coupin remarks that it is somewhat difficult to determine the exact time of the plant's death since it is rather hard to distinguish between a seedling which is already dead and one which is at the point of death, and since, moreover, among the same lot of seeds, which are quite identical to all appearance, some produce seedlings which live longer than those produced by others. With this reservation he presents the following table, which should be of great interest not only to botanists but to practical agriculturalists.

| Plants observed. | No. of days required to produce death. |
|---|---|
| Nut-bearing pine | 60 days of inanition |
| Pumpkin | 46 " " |
| Winter vetches | 44 " " |
| Lentils | 40 " " |
| Marvel of Peru | 39 " " |
| Peas | 33 " " |
| Haricot beans | 32 " " |
| Sunflower | 30 " " |
| Gray buckwheat | 25 " " |
| Radish | 24 " " |
| Nasturtium | 23 " " |
| Spinach | 22 " " |
| Tomato | 21 " " |
| Beet | 20 " " |
| Common cress | 18 " " |
| Mustard plant | 18 " " |
| Provence Lucerne | 15 " " |

As we see, this table shows a very remarkable variation in resistance ranging from a power to live for two months on water alone, to a resistance which succumbs in one fourth of that time. These differences obviously depend, according to M. Coupin, upon the more or less resistant nature of the organism itself, and in particular upon the abundance and the character of the reserve materials at its command.

## THE DUMB CANE

ONE of the most attractive of our native wild flowers is the Jack-in-the Pulpit, whose graceful spathe pierces the mold of our forests in early spring. In the fall this spathe has withered and the central spadix—the "Jack" of the spring—is covered with brilliant red berries, not only handsome but very edible in aspect—but in aspect alone. The writer well remembers tasting one of them tentatively, merely inserting her teeth into one of the scarlet fruits—for several hours thereafter her tongue felt as if it were serving as a pincushion for a thousand tiny red hot needles! The Jack-in-the Pulpit, in fact—or Indian turnip as it is also known—belongs to the family of the *Araceae*, which are characterized by an extremely acrid and poisonous juice. Most of this family, of which there are something like a thousand species, are natives of the tropics, and in these this acrid principle is apt to be highly toxic. One, indeed, the *Dieffenbachia seguina*, found in the West Indies and in South America, is popularly known as the *dumb cane*, because if it is chewed it causes the tongue to swell so that the victim is unable to speak. However this poison can be removed by cooking or by washing, and many of the species bear tubers which abound in starch, and furnish a wholesome and nutritious food when properly prepared. The Indian turnip is so called, in fact, from the fact that it was eaten by certain tribes. The handsome plant known as the Wake-robin, the cuckoo-pint, and sometimes picturesquely termed "lords-and-ladies" (the *Arum maculatum*) is used for making arrow root.

Another species which is extensively cultivated in tropical countries for food is the taro. The best-known examples of this family in our own temperate zone are the Jack-in-the Pulpit, the skunk cabbage, as beautiful to behold as it is offensive to come near, and the sweet flag or calamus.—*May Tevis.*

## INDIAN USES OF KELP—CORRECTION

IN our issue of February last we published an article entitled "Indian Uses of Kelp." Our attention has been called to a typographical error in the name of the author. The article was credited to J. C. Leachman instead of J. D. Leachman.

GATHERING ROSES AT RAHMANLARI, ON THE SUNNY SLOPES OF THE BALKANS

# The Attar of Roses

## French and Bulgarian Methods of Producing the Essential Oil of Rose Petals

By May Tevis

HAD nature confined that royal flower, the rose, to a remote and almost inaccessible region of the earth, instead of lavishing it by the wayside in nearly every country upon the globe, men would travel thousands of miles and brave untold hardships and dangers for a glimpse of its incomparable perfection of color, form and grace. But lavishly as it is spread at the feet of mankind, nothing can stale its beauty and its charm. In every nation and in every age poets have made it the theme of their loveliest lays. In Persia the romantic fancy of generations of poets linked its name with that of the most enchanting of birds, the shy nightingale, and in their primeval *naïveté* they saw nothing incongruous in making the bird the romantic lover of the blossom, pouring forth its praises under the star-filled skies.

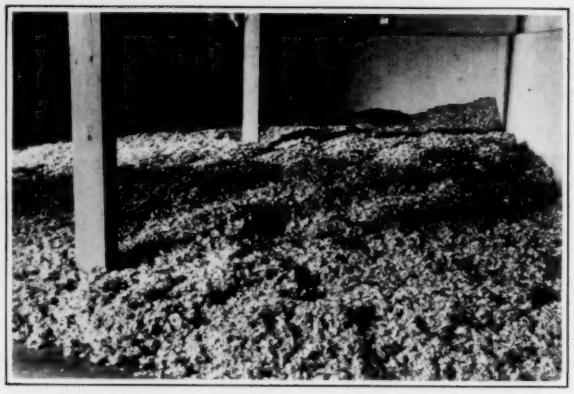
But supreme among the charms of the rose is its exquisite and haunting fragrance, a fragrance at once delicate and powerful, and so persistent that it may cling for months to a fabric, the page of a book, or the shattered fragment of a vase. Small wonder that the ancients felt the perfume to be the soul of the rose, or that they sought some means of holding it fast when the blight of winter had withered the lovely petals of the flower.

It was sought by various means to accomplish this devout purpose. Layers of petals interspersed with layers of salt and spices—the famous potpourri of our grandmothers and their forbears—was one method. Another was the making of rose water.

It is not known positively who first discovered the method of extracting from the petals the pure oil or attar of roses—this by the way is also known as the otto of roses, but since the late European unpleasantness that word somehow has a disagreeable connotation, so we shall avoid it in this article! This oil, or attar, or essence, is produced by distillation and it was probably the Arabs who discovered this art and introduced it into Europe. There is an old book in the National Library in Paris, from which we learn that during the reign of the Caliph Mamoun (810 to 817 A. D.) in Persia, the province of Faristan was required to pay an annual tribute of 30,000 bottles of rose water to the treasury of Bagdad. But while the essential oil or attar was described by Rossi in the latter part of the 16th century, it was not discovered or rediscovered in Persia until 1612, and then by accident, according to the pretty story told in the *Annals of the Mongolian Empire*, an old work written by a Venetian physician named Manecci. As the tale runs the Princess Nour-Djihan being betrothed to a visitor from Paradise, the Prince Djihan-guir, arranged a fête in his honor to celebrate the festival of the New Year. Being minded to show her skill in the womanly arts of the day, she and her maidens prepared for him a gift of rose water. But not content with offering a few flasks, the princess displayed the lavishness of her affection and her wealth by filling with the precious fluid the bed of an artificial stream, which she caused to be made within her luxurious garden. Here as the great lady and her lover walked to take the air they observed that the surface of the rose water beside whose channel they were strolling, was covered with a delicate oily film. When this was collected and examined the royal couple and their court were enchanted to find that their vials held the very soul of the rose, its essence.

But while the rose gardens of Persia and the precious attar distilled from their petals will never fade in our memory, the great bulk of this valuable product is now made in the Balkans. It is Bulgaria that is today the Rose Garden of the world. The earth beneath and the air above the sunny slopes of the Balkans contain the elements most fitted to be transformed by nature's alchemy into the miracle of the rose. The soil on these slopes is extremely fertile, being composed chiefly of crumbled syenite. The chief center of the industry is Kazanlik and around this town stretch thousands of acres covered with roses, the area under cultivation lying between the 24th and 26th degrees of longitude east and the 42nd and 43rd degrees of latitude north. Besides their advantages of sun, soil, and air, these Balkan slopes furnish two other indispensable means for the work of distillation; water and fuel.

In the height of the season as far as the eye can reach it is greeted by gorgeous masses of color from the rich crimson blossom of the *Rosa Damascena* grown in fields bordered by hedges of white roses, the *Rosa Alba*. This picturesque arrangement of contrasting colors is not due to any esthetic sense on the part of the Bulgarian grower, however; it is due alas to a very sordid motive! While the white rose is much poorer in perfume than the damask rose, it is richer in the chemical substance called stearoptene, and this substance, as we shall see, facilitates fraud by making it easier to adulterate the final product.



A MORNING'S GATHERING OF ROSES IN A FACTORY AT RAHMANLARI

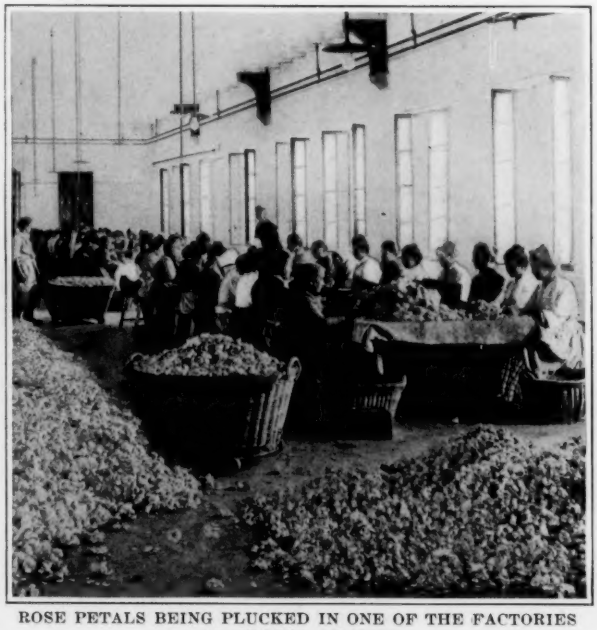
The pile averages a foot in thickness and weighs 10,000 lbs.

The flowers are gathered before they begin to open, just when Aurora is spreading drifts of rose petals upon the sky. In no case does the picking of the flowers continue later than 10 or 11 o'clock in the morning, unless the sky be overcast with clouds, since it is of vital importance that they should not be gathered while the heat of the sun is upon them. A properly planted garden, well taken care of, yields about 100 pounds of flowers per day for about three weeks. The roses are carried to some one of the many distilleries in the district as quickly as possible. It is considered imperative to distil them the very day they are gathered, since if kept for even 24 hours the oil is less fine in quality.

### THE METHOD OF DISTILLING

Most of the distilleries are rather rough, being hardly more than wooden sheds. The stills are arranged in rows as shown in our illustration. They consist of copper alembics about 3 to 5 feet in height, resting on a furnace built of bricks. The average contents of each still is about 20 gallons, the charge usually being 10 kilos of flowers and 75 liters of water.

The condenser is a straight or worm tube passing through a vat of water, into which cold water continually runs. A brisk fire is kept up for an hour to an hour and a half, and when ten liters of liquid are obtained the fire is drawn. At times 15 liters are distilled over, but the result is an attar containing a larger amount of stearoptene. The still is then opened and the spent petals, or rather flowers, for the green parts are seldom separated, are thrown away, and the residual hot water is returned to the still with cold water to make up the 75 liters, with a fresh charge of flowers. This operation is repeated until, as a rule, 40 liters of rose water have been collected. These 40 liters are now distilled, and the first 5 liters are collected in a long-necked flask. The residual 35 liters are used for distilling fresh flowers. The 5 liters distilling over are cloudy, and the oil drops gradually rise and collect in the neck of the flask. When it has all risen, it is removed by a small tin funnel with a tiny orifice for the water to be drawn off. The yield is variable, a warm humid spring with intervals of strong sunshine being more favorable than an uninterrupted dry season. The average yield in Bulgaria is about 1 kilo of attar from 3,000 kilos of rose leaves.



ROSE PETALS BEING PLUCKED IN ONE OF THE FACTORIES AT GRASSE, FRANCE

### CHARACTERISTICS OF THE ATTAR

Pure, carefully-distilled rose oil is at first colorless, but soon turns yellowish; this, however, applies only to Bulgarian oil; French and Saxon rose oils have a greenish color. Its specific gravity is between 0.830 and 0.890. It consists of a liquid oil and a stearoptene, the content of the latter varying very much; it is a pure hydrocarbon, odorless, of specific gravity 0.840 to 0.860, and distills at 572° F. Hence it is lighter than the elæoptene to which alone the scent of rose oil is due. Rose oil generally congeals between 50° and 60° F., though sometimes at a higher or lower degree, according to its content of stearoptene. While some oils require the cold of winter for congealing, others are in the heat of summer either entirely solid, or form a fluid filled with many crystals. The odor of rose oil is peculiarly honey-like, and too strong to be agreeable, its entire deliciousness being only developed by great dilution in water or alcohol, or by distribution upon large quantities of solids such as fats, soaps, etc. In alcohol it dissolves with greater difficulty than all other volatile oils, 1 part of it requiring for solution 140 to 160 parts of alcohol of 0.815 specific gravity.

The larger or smaller content of stearoptene in rose oil seems to be dependent on climate, the quantity being greater the lower the temperature. The oil from the coldest and highest regions of the Balkans is richer in stearoptene than that from the lower and warmer regions.

The genuineness of rose oil is generally judged by its odor, its capacity of congealing, and the manner of its crystallization. The odor is the best test, but requires much experience and especially reliable pure standard samples for comparison. The capacity of congealing at certain conditions of temperature is also a requirement of genuine rose oil, but this property varies greatly and is subject to different influences, so that a fixed standard at which pure rose oil must congeal cannot be established. But the quality of a rose oil does not rise with its greater capacity to congeal, since only the liquid oxygenated portion is frequent. The well-known German firm, Schimmel & Co., have put on the market a liquid rose oil freed from stearoptene which can be highly recommended for finer alcoholic perfumes. It remains fluid at

32° F., but in a cold mixture congeals to a gelatinous mass, and hence is not absolutely free from stearoptene. It has an extremely fine and powerful odor, and when dissolved in alcohol does not give the disagreeable crystalline separations of the ordinary rose oil, which are disturbing, especially in making extracts.

For the insulation and determination of the stearoptene in rose oil, Schimmel & Co. proceed as follows: Heat 50 gr. of oil together with 500 gr. of 75 per cent alcohol to from 158° to 176° F. In cooling the stearoptene separates nearly quantitatively. Separate it from the fluid, treat it again in the same manner with 200 gr. of 75 per cent alcohol and repeat the operation until the stearoptene is entirely free from odor. Two treatments of the crude stearoptene are generally sufficient. In this manner Schimmel & Co. obtained from 1887 German rose oil 32½ per cent stearoptene, from 1888 German rose oil 34 per cent, from 1887 Turkish rose oil 12 to 13 per cent, and from 1888 Turkish rose oil 14 per cent.

AN OUTDOOR STILL IN SOUTHERN FRANCE

The chief adulterant used by the Bulgarians is the so-called geranium oil, which is really ginger-grass oil from India brought by way of Arabia to Constantinople, and prepared for adulterating rose oil by treatment with lemon juice and bleaching in the sun. The brand is generally made by sprinkling the ginger-grass oil thus prepared upon the rose leaves before distilling. The general characters of this oil are so similar to those of rose oil that detection is very difficult, so that during the distilling time large buyers and exporters of rose oil are forced to pay confidential native agents who constantly move around in the distilling regions and report where distillation has been carried on honestly, and where the ginger-grass oil bottle has been seen. However, the prepared ginger-grass oil is frequently not even distilled with the rose leaves, but simply mixed with the finished rose oil.

Whether a rose oil is free from geranium or ginger-grass oil is tested in Bulgaria, according to Christo Christoff, by the freezing method, which is, however, unreliable. It is based upon the fact that an addition of geranium oil reduces the congealing point of rose oil. Pure Bulgarian rose oil congeals at from 63.5° to 68° F.; by the addition of geranium oil, the same oil congeals at 61.25°, 59°, 56.75°, or at a still lower temperature, according to the quantity added. The buyer when purchasing oil carries with him two basins, one containing hot and the other cold water which he mixes in order to obtain a fixed temperature, the operation being controlled by a Réaumur thermometer. In the water thus prepared he completely submerges a 20 gram flask containing 15 gr. of the oil to be tested. In three minutes, needle-like crystals of the separating stearoptene must appear, and in ten minutes crystallization must be complete. According to the congealing point thus established, the produce is paid for. Oil congealing below 59° F. being evidently adulterated is rejected and bargained for at a special price.

Many attempts have been made to make this congelation appear within the limits of temperature permitted, paraffin which dissolves well in rose oil being formerly frequently added. In such case the oil may congeal at from 65.75° to 68° F., but the crystals are opaque, dirty yellow, and dissolved to a turbid paste which collects on the surface. The simplest method is to distil white roses with the red. The product has not so fine an odor as that from red roses alone, but is richer in stearoptene. Such oil, which, unadulterated, congeals perhaps at 68° F., can by the addition of geranium oil be reduced to from 63.5° to 65.75° F., thus keeping within the limits permitted.

Numerous attempts have been made to find a rapid and sure way for the detection of geranium oil in rose oil, but thus far in vain. Attention must also be drawn to the fact that

A BATTERY OF NATIVE STILLS USED FOR EXTRACTING THE ESSENTIAL OIL OF THE ROSE

the adulterant is frequently itself adulterated with oil of turpentine before being sold to the distillers of rose oil.

Besides the above-mentioned ginger-grass oil, the actual geranium oils from *Pelargonium odoratissimum* and *P. roseum*, as well as rose-wood oil, sandal-wood oil, spermaceti, paraffin, and fat oils have been used to adulterate rose oil. But the geranium oils having a by-odor of lemon oil by which their presence can be readily detected are not suitable. Neither are rose-wood or sandal-wood oils; such adulteration would be so clumsy as to be immediately recognized. Attempts to adulterate rose oil by the addition of a fatty crystallizable body together with another volatile oil fail on account of the characteristic properties of *rose-oil stearoptene, which resembles no other body at present known.* While rose-oil stearoptene is lighter than elæoptene and entirely volatile, spermaceti possesses essentially different qualities. It does not form such long and specifically light crystals as rose-oil stearoptene; hence it readily separates on the bottom and on shaking exhibits a peculiar iridescent loamy formation. Furthermore it melts at 122° F., and, not being volatile, leaves, on heating a greasy stain upon paper, while the stearoptene melts at 95° F. and, on heating, volatilizes completely without leaving a stain.

### HOW TO TEST ROSE OIL

If a rose oil is to be tested, expose the bottle containing the oil to a moderate heat until the contents are entirely liquid; then gently shake the bottle in order intimately to mix the elæoptene and stearoptene. Now pour some of the oil into a cylindrical glass flask of 20 to 40 cubic centimeters' capacity and allow it to congeal; then, while heating in the hand observe how the rigid portions act in liquefying. These rigid, crystalline portions should be transparently clear and should float, while melting in the upper layer of the fluid. Hence, when the fluid be again allowed to congeal, the crystals should appear within the upper half of the oil. The above-mentioned volatile oils partially lack the property of separating a stearoptene in crystals from 33.8° to 50° F., and though they may have a rose odor, it is not the mild, fragrant odor of genuine rose oil. To recognize the latter, Guibourt makes use of pure concentrated sulphuric acid. Stir together in a watch-crystal an equal number of drops of the oil and of the acid; pure rose oil preserves its characteristic odor, while the foreign oils exhibit a disagreeable odor even when mixed with genuine rose oil.

French attar has a clear and penetrating perfume similar to that of the freshly cut flower.

In France only steam stills are used, to the exclusion of apparatus used with open flowers, which in burning the flower somewhat imparts to the essential oil a slightly burnt odor from which the French attar is free.

The characters of attar of rose vary considerably according to the locality in which the plants are grown, and also in one locality from season to season according to climatic and other conditions. All these factors must be taken into consideration in forming an opinion on attar of rose, and it must be remembered that no published figures can be accepted as final or exhaustive. The following may be taken according to Parry as being typical, however, of the best attars produced in various localities:

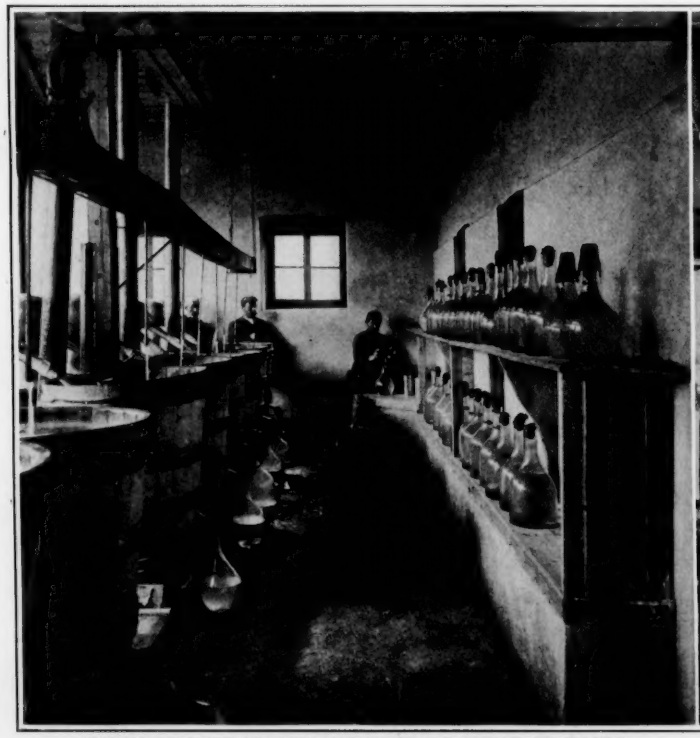
### BULGARIAN ATTAR OF ROSE

| | |
|---|---|
| Specific gravity at $\frac{30°}{15.5}$ | 0.849 to 0.858 |
| Optical rotation | —1°30′ to 1.4650 |
| Refractive index 25° | 1.4580 to 1.4650 |
| Melting point | 19° to 22° |
| Total alcohols | 68 to 78 per cent |
| Citronellol | 28 to 34 per cent |
| Acid value | 0.1 to 0.3 |
| Ester | 0.7 to 1.2 |
| Stearoptene content | 15 to 20 per cent |

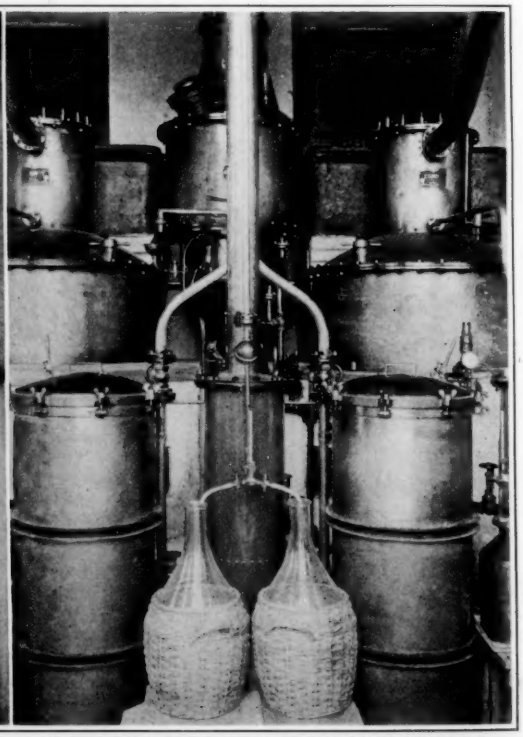
### FRENCH ATTAR OF ROSE

In France numerous different roses are distilled, each yielding its own characteristic attar, so that the resulting products will vary according to the percentage of each given rose in the distilling material.

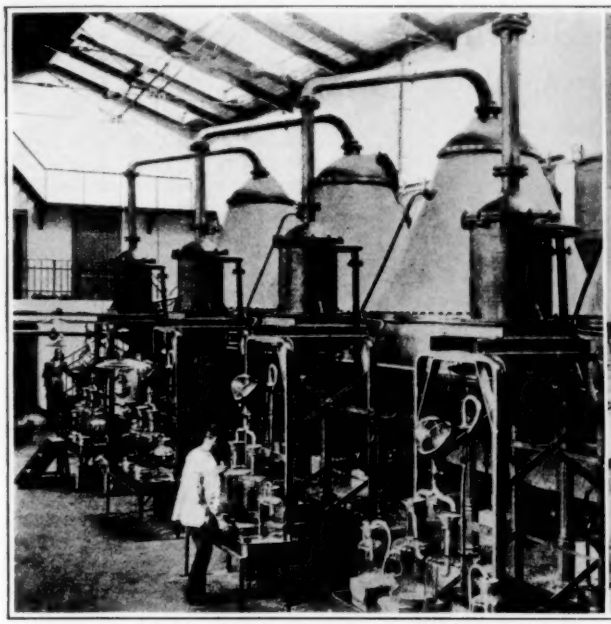
In 1904 Jeancard and Saltie (*Bull. Soc. Chem. de Paris*, 1904, 934) published a paper dealing with the analysis of



TANKS OF ROSE WATER AND BOTTLED ATTAR OF ROSES



A MODERN STILL IN A BULGARIAN FACTORY



STILLS IN A FACTORY AT GRASSE

ROSE WATER IN THE CELLAR OF A FACTORY AT GRASSE

attar of roses. They distilled a sample from the sepals only of *Rosa centifolia*, and found it to have the following characters:

| | |
|---|---|
| Congealing point | 8° |
| Stearoptene | 51.13 per cent |
| Specific gravity | 0.8704 at 15° |
| Rotation | —41° |
| Melting point of stearoptene | 14° |
| Acid value | 6.12 |
| Ester | 16.28 |
| Total alcohols | 13.99 per cent |
| Citronellol | 13.56 per cent |

(*We are indebted for these figures as well as much other valuable information to the admirable volume by Parry on "The Chemical Properties of Perfumes," published in 1918.*—EDITOR.)

## THE CARE AND AGING OF PERFUMES

By L. J. ZOLLINGER

THE tanking and conservation of perfumes involves a very careful study of the effects upon the product of the various metals or other materials of which tanks, pipes, funnels, funnel supports, pumps and other paraphernalia are made. Discoloration and deterioration, due to oxidation, too frequently result from ignorance of this elemental consideration.

As a case in point, let us take monel metal, once regarded as the alloy *par excellence* for the purposes of manufacturers of certain pharmaceutical preparations, to store essence of pepsin, for example. It was later discovered, to the chagrin of the industry generally that monel metal contains iron, which is a dire threat to many modern perfumes containing synthetic products, such as Indol, Methyl Anthranylate, Heliotropin, Vanillin, compounds of Iso-Eugenol or any of the Salicylates.

Galvanized iron is bad, as is so-called agate ware. Enamel would be satisfactory if absolute perfection of quality were to be had in this country. Aluminum containing trace of iron is taboo. Copper should not be employed unless heavily tin coated and, even then, it should be relined once a year, and be so constructed as to permit of convenient inspection.

Earthenware of good quality makes excellent containers. Some perfumers here and abroad have used silver-lined tanks with satisfactory results. Silver-lined faucets are desirable. Brass corrodes or oxidizes and is therefore unsuitable. The top opening of the tank should be hermetically sealed.

Glass-lined tanks are most desirable for the perfumer's every purpose. They should be thoroughly cleaned and carefully inspected before the mixing of a new batch.

Rubber gaskets and washers should be employed with utmost discretion, since they dissolve in alcohol and, especially, in concentrated perfumes. Use rubber washers only where they do not come in contact with the extract, as on the outside. A ground steel V-joint is always efficient, since it can be made very tight and thus remove all danger of evaporation.

In trans-vasing, as in storing, extreme care is demanded. Never use rubber tubing, for the same reason as given in relation to rubber gaskets. Block tin or silver is appropriate to the purpose. Store the alcoholic tinctures—Musk, Civet, Ambergris—in glass demijohns away from the light and in a moderately warm temperature. Never make or store Orris Root tincture in tin percolators and never store it in tin tanks—the extreme of folly.

Don't—if you can avoid it—allow a small quantity of a perfume to remain long in the tank. This makes for oxidation, decomposition and deterioration. It is considered good practice, for example, where the original batch is 100 gallons, to draw off and place in a suitable container the final 10 gallons.

No experienced perfumer needs to be warned to arrange his store room of bulk perfumes in a cool, dark place, kept scrupulously clean and in apple-pie order.

The aging process depends altogether on the composition of the product. The heavy natural bouquet odors improve tenfold by aging, whereas many new-type odors based upon artificial ingredients will not stand aging. The quicker the latter named perfumes are bottled and sold, the better.

Discoloration frequently does not take place immediately upon contact with the wrong metal but may occur long afterward, when the goods are for sale in the retail store. A discolored product is absolutely fatal to the sale. It should be crystal-clear, well filtered, brilliant. Tint it if necessary.

When pomades were so extensively used it was recognized as vital and necessary to chill and filter the washings of flower bases. Owing to the ease in using liquid flower essences made by the volatile-solvent process, perfumers are becoming somewhat lax in this respect. But the perfumer who plays sure will test his finished product by chilling a small quantity from the batch to, say 30° to 32° F. Then and only then can he be assured that there will be no deposit in winter.—*Montreal Pharmaceutical Journal*, Jan., 1921.

# What is Manna?

## Modern Varieties Compared with the Biblical Food

By T. A. Marchmay

A VERY absurd report has recently gone the rounds of the newspapers, purporting to be a consular report to the effect that "manna still falls from the skies like dew and is collected and eaten as in the days of the ancient Hebrews, but it only survives the night when it falls upon the oak tree; on other trees it immediately withers away."

Because of the wide publicity this statement was given it seems worth while to correct its errors and state the facts, which happen to be quite interesting.

To begin with, dew itself does not fall from the sky but is produced by the condensation of moisture. In the next place there is no direct connection whatever between dew and manna.

Manna is the term applied to the dried sap of certain trees containing a chemical compound known as mannite. It is produced on a commercial scale in modern times, most of it coming from Sicily. It is shipped to drug supply houses in various parts of the world. The writer has bought and eaten it within the last few days. It was obtained in one of the well-known chain drug stores.

The manna that comes from Sicily is a sweet substance that exudes from incisions in the stems of *Fraxinus ornus* and other species of ash. During July and August incisions are made in the trunks and larger limbs of the trees, and if the weather be warm the manna begins to ooze from the cuts and harden into lumps or flakes which are removed by collectors. Manna is a light porous substance of a yellowish color, not unlike dried honey. There are different qualities found upon the market, which vary in their purity and composition. Flake manna is obtained when there is an abundant flow from the upper incisions. It dries into flat pieces or tubes and differs somewhat in composition from the other varieties. Small, or talfa, manna occurs in tears from the lower incisions and is less crystalline and more gummy. Fat manna is brownish, viscid, non-crystalline, and is usually full of fragments of bark and other impurities. Manna is largely used in medicine as a laxative, demulcent, and expectorant, and is commonly administered with other medicines, as senna, rhubarb, etc. Its constituents, as reported by many investigators, are mannite 60 to 90 per cent, glucose, mucilage, fraxin, resin, etc. In addition to its value in medicine, manna has been extensively used for food, its value for this purpose depending upon the carbohydrates present.

In addition to that produced by various species of ash, manna or substances resembling it are excreted by many other species of plants. In Australia various species of Eucalyptus produce what is called manna or lerp. This saccharine substance is said to be without the laxative properties of true manna and is eaten as food. Similar substances are obtained in Australia from the tea tree (*Leptospermum scoparium*), sandalwood (*Myoporum platycarpum*), and Australian blue grass (*Andropogon unnulatus*). During a famine in India a manna-like substance was exuded in sufficient abundance from a species of bamboo (*Dendrocalamus strictus*) to form an important food supply in some districts. It did not contain any mannite, the principal characteristic of true manna. Similar substances are obtained from the common larch of Europe (*Larix decidua*), the substance being known as Briancon manna; from *Quercus vallonea*, called Armenian manna from *Alhagi camelorum*, camel's thorn; tamaris manna from *Tamarix gallica mannifera*, believed by some to have been the source of the manna of the Israelits, while others attribute it to a lichen (*Lecanora esculenta*); American manna, from the sugar pine (*Pinus lambertiana*); California manna, believed to be deposited from *Phragmites communis;* etc. Some insects, as *Lavinus mellificus*, secrete a similar material. All of these saccharine substances are usually grouped together as false manna. They contain as their principal constituent melitose or melezitose, but no mannite. A large number of plants yield small quantities of mannite. For a discussion of their chemical composition, consult *Tollens Handbuch der Kohlenhydrates* (Breslau) 1895.

### THE MANNA OF THE BIBLE

According to the biblical account, manna was the chief food of the Israelites during their 40 years' wandering in the desert (Ex. xvi.; Num. xi, 6-9). It is described as falling from heaven like rain or with the dew; small, round and white, like coriander seed; in taste, sweet like honey, or like fresh oil. It was gathered in the morning and it melted when the sun rose. A sufficient amount was provided daily for each individual and no more; if a surplus was gathered, it spoiled before the succeeding morning. On the sixth day, however, a double portion was provided, and none could be found on the Sabbath. It could be ground in a mill, beaten in a mortar, baked and made into cakes, or boiled. A command was given to preserve an omer of it in the ark of the covenant for future generations. (Cf. Heb. ix, 4). The supply ceased on entrance into the promised land. (Josh. v, 12.) In Ex. xvi, 15 the name is explained by a reference to the exclamation of the Hebrews when they first saw the manna and knew not as yet what it was, *man* being made equivalent to *mah*, "what is it?" This explanation is probably a species of popular etymology and indicates that the true origin of the word was unknown. In the later literature manna is called "corn" or "bread of heaven" and "angel's food." (Ps. lxxviii., 24-25, cv. 40; of John vi, 31; 1 Cor. x, 3.) Attempts have been made to explain the biblical manna as the exudation from the tarfa tree, a species of tamarisk (*Tamariz gallica mannifera*), or the camel's thorn, or as lichens. Manifestly such an explanation fails to satisfy all the conditions of the narrative. It is believed, however, that the latter represents an early tradition with later embellishments, the view becomes plausible that the use of some such food by a small tribe or clan in time of need may have formed the basis of the narrative. The passage in Numbers is attributed to the Yahwistic writer, and hence to preëxilix; that in Exodus is found in the priestly narrative, but it probably embodies certain old fragments with considerable additions by the redactors. Consult the commentaries of Dillmann, Baentsch, and Strack on Exodus xvi.

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### SAVE THE DOGWOOD!

IF popularity may be judged by the frequency of picking, the flowering dogwood may be said to be one of our most popular wild shrubs. From the time it begins to bloom in the spring, until the last flower has dropped, there is a continual procession, both afoot and in the automobiles to its haunts in the woods. The white spread of blossoms, as seen from the roadside, acts as a challenge to the passerby to enter and pick. Boys daily come trooping back to town with their arms full to dropping; automobiles return from their afternoon's ride in the country, their wind shields covered with the snowy white blossoms. A successful day! But let us ask ourselves if it was success? Rather, was it not thoughtless vandalism? The continual breaking of the branches and the cutting down of the whole of the smaller trees, is diminishing our dogwood to such a degree that there is danger of our losing these shrubs in localities accessible to towns, villages and cities.—Inez M. Haring in *American Forestry*, April, 1921.

# Radioactivity and Soil Fertility

## Some Important Researches by Professor Gabriel Petit, of Alfort, France

THE study of the remarkable phenomena of radioactivity has so profoundly modified our theories in every department of scientific thought as well as our practice in many branches of applied science that it is not strange that many investigators should have sought to discover whether this strange property of certain kinds of matter may not be utilized to advance that most ancient and vital branch of human endeavor, the science and art of agriculture. In 1913 the French Academy of Sciences testified to the importance of the subject by appropriating from the "Bonaparte Fund" several allotment subsidies of 2,000 fr. for the study of the influence of radioactivity upon the development of plants in general, and particularly upon "*the mutation, the reproduction, and the variation of certain species of plants.*"

One of the most prominent and successful among the French investigators along this line is Prof. Gabriel Petit of Alfort, a member of the French Academy of Medicine, but known as an enthusiast on botanical research. This authority does not hesitate to declare, as the result of several years of research that properly employed "radioactive energies" can be of very great value indeed in this domain. Professor Petit has contributed to *La Nature* (Paris), for October 16, 1920, an account of his more recent experiments in this field, of which we present the following résumé. As we know radioactive bodies emit three kinds of rays: 1. The *alpha* rays, which are positively electrified atoms of helium; 2. The *beta* rays, which are likewise corpuscular but which are negatively charged; 3. The *gamma* rays, which are immaterially vibratory and comparable to the X-rays from which they differ, however, by their penetrability, since some of them, sufficiently tenuous to pass through the interval of space between the atoms—there is no other explanation—succeed in traversing sheets of lead from 20 to 30 cm. in thickness. This is the so-called "*ultra penetrant*" *radiation* filtered by means of a rigidly exact technique which is employed particularly and with great efficacy in the treatment of cancer by means of Radium-therapy or Mesothorium-therapy.

Since radioactivity, whose characteristic feature is in Professor Soddy's expression "a continual emission of energy" in the form of heat, electricity, and continuous vibratory and atomic projections, is it not reasonable to suppose that at low intensities it may exert a favorable influence upon vital phenomena, whether in men, in animals, or in plants?

Putting aside men and animals if we wish to give an immediate demonstration of the fact that radioactivity is capable of exerting a remarkable influence upon vegetation, we have but to choose among the most striking results of the experiments, still unpublished, which we have carried on at the School of Alfort with the skilful collaboration of M. Guillemain, the head gardener, a former pupil of the School of Horticulture at Versailles.

Let us take, for example, the tests conducted with potted plants after slipping. Two geraniums of the same age (variety Destinée) were grown side by side in pots, one being given the treatment while the other served as a control. Photographs of the pot show the former to be far more luxuriant, making the latter look sickly in comparison! But the two pots were exactly alike with respect to the earth which filled them, of which each contained 2.5 kg., the only difference was that in one of them 15 grams of a substance produced by the activity 0.11,[1] (*i.e.* with respect to the activity of uranium oxide which is taken as a unit) had been placed in the pot and intimately mixed with the earth at the beginning of the experiment on the seventh day of the previous May. The results obtained were photographed at the end of the three months.

Thus we see that this marked result of improved growth was produced by the infinitesimal proportions of 0.60 gr. per 100 gr. of earth, of the radioactive stimulant, since all of the surrounding conditions as well as the later treatment (open air, illumination, temperature, watering, etc.) were precisely identical for the two plants.

A second experiment of the same kind, but conducted on a larger scale, since it included 40 chrysanthemum plants, would seem even more interesting with respect to the peculiar radiosensitiveness[2] of the plant selected and to the importance of the dose. These 40 pots comprised: (1) 10 control pots; (2) 10 pots containing a total amount of 200 gr. of the same substance as before, having an activity of 0.11 (the proportion being 8 per cent); (3) 10 pots containing 300 gr. (the proportion being 12 per cent); (4) 10 pots containing 400 gr. (the proportion being 16 per cent). The experiment was begun June 16 and the plants were photographed August 2, before blooming. Photographs of a single plant chosen at random from each of the four lots and placed in order with the control plant first, exhibited a marked and steady progress in height and luxuriance of growth from the first to the last.

But we have not yet determined the amount of the toxic or fatal dose for each plant studied, though this information would be extremely interesting; such a dose, however, would probably be very large.

It is worth noting, however, that we exceeded without any inconvenience, on the contrary, the proportion of 10 per cent of the complementary radioactive excitant of the fertilizer, which was recommended to agriculturists.

We might multiply these examples indefinitely[3] and might speak likewise of the seeds sown in pots (oats, clover, lupine, vetch, etc.), which as a general thing produced equally satisfactory results—or we might mention our experiments in plant cultivation upon a large scale, *i.e.*, in the open ground, which concern beans, cabbages, leeks, etc., and are not yet completed.

If we admit that low degrees of radioactivity exert a favorable effect upon the growth of plants—a fact which it would be difficult to deny, in our opinion, in the light of the foregoing observations—how shall we explain it while awaiting the results of more extended and more rigorous experimentation? The problem is, indeed, both subtle and complex and fairly bristles with unknown points. But is this a reason for avoiding its consideration? Is it not true on the contrary that the deeper the enigma the greater its fascination for us? Let us reflect that the development of a mere seed planted in the ground holds our interest—that this soil is composed of a mixture which is essentially variable in character of organic and of mineral substances, some of which are present naturally, while some have been added in the form of fertilizers—let us remember, finally, that this soil contains a prodigious number of micro-organisms of all sorts without whose presence all life would be extinguished and some of which are useful while others are injurious.

Then let us put to ourselves the question as to what manner of effect radioactivity applied in the optimum dose will exert either directly or indirectly, first, *upon the plant* to stimulate it and increase its vigor; second, *upon the earth* to produce possible favorable modifications of its character so as to adapt it the better to the requirements of assimilation[4];

[1]Due to the kindness of the Sôciétié Française d'Energie et de Radio-Chimie.

[2]Already demonstrated in 1913 by M. Viand-Bruyant, the distinguished Poitiers horticulturist in experiments which he kindly undertook at our instance.

[3]Our experiments upon the brilliant sage, fuchsias, and anthemis gave the same perfect results.

[4]Prof. Daniel Berthelot, member of the Institute, Director of the Station of Plant Physics at Mendon, who was the first observer to note the withering of vegetation through radioactivity, has shown that a feeble electric current activates the decomposition of organic matter and thus renders it more assimilable.

and finally, *upon the microbes* themselves to augment or decrease their vitality as the case may be.

### THE DIRECT ACTION OF RADIATION

As yet we hardly know which radiations are most effective in their action upon plants. Does this superior effectiveness belong to the *alpha* rays which are intercepted by the most fragile obstacle, but which are none the less electrified atoms, or to the *beta* rays and the *gamma* rays, which are more penetrating although they are divided into "soft" rays and "hard" rays? Since as yet we do not know how to dissociate their values[5] let us consider, while awaiting fuller information, the total radiation.

It is evident that the plant may be killed if too large a dose of the radioactive treatment be given, whereas, if a moderate and suitable dose be applied it will be, on the contrary, stimulative.

My late collaborator and friend, Dr. Henri Dominici, whose name will always remain associated with the employment of ultra-penetrant radiation in the treatment of cancer, proved by microscopic research upon animals that certain rays given off by radium are capable of occasioning through the integument either the necrosis of the conjunctive, dermic, and hyperdermic cells, *i.e.*, their instant death, or else their vigorous proliferation—the difference of effect being merely a question of the amount of the dose. How much more then would this hold true in the case of the amount of our young, sensitive, delicate plant cells, which are, moreover, more directly exposed since they belong either to the roots or to the embryo of the seeds.

### EXPERIMENTS IN GERMINATION

M. Mattout, a collaborator of Professor Becquerel at the Museum of Natural History, readily succeeded in sterilizing the seeds of cress and of mustard by strong irradiations which proved fatal. In the same way M. Guilleminot operating with other seeds observed possibly for the first time under these conditions the accelerating action of low degrees of activities. Dr. Nogier,[6] associate professor of the Faculty of Medicine of Lyons, who is well known through his important works upon radium therapy, has made experiments with the seeds of annual plants, such as the balsam, larkspur, poppy, and clarkia, placed in boxes of thin cardboard to intense radiation from an apparatus containing assembled salts probably similar to those employed in dermatology. Naturally, in the formidable and destructive doses of 6,240 and 3,570 or 600 milligram-minutes.[7] He could not fail instantly to destroy the germinating power of most of these seeds. However, a few among them (Clarkias) which doubtless lay at the bottom or in the angles of the box and were thus comparatively protected and subjected only to considerably attenuated irradiations, were not only not killed, but after making a rather reluctant start they greatly exceeded in vigor of growth the control plant which had not been irradiated. This forms a demonstration—still quite imperfect, to be sure, but nevertheless convincing, of the exciting power, as the author expresses it of feeble doses of radium.

Together with M. R. Ancelin, an agricultural engineer, we ourselves previously to Dr. Nogier established the fact in a note prepared for the Acadamy of Sciences[8] of the favorable influence exerted by direct radioactivity upon germination. By allowing a specimen of water radioactivated to a known degree in comparison with ordinary water to operate upon various seeds (wheat, maize, barley, ray-grass), we were able to observe not once merely but *constantly* in all the lots treated that the rootlets and the stemlets proceeding from the embryos thus irradiated were incomparably larger and stronger! How shall we explain this impressive result if not by the increased intensity of the cellular multiplication under the durable and permanent action of feeble iradiation?

As soon as the contact is established—a contact let us remark which is increasingly intimate in proportion as the roots extend into a previously prepared soil—between a radioactive substance emitting electrified rays and the plant which receives the disturbance and shock due to these, it becomes *a priori* impossible that the plant should not be influenced either for good or for ill by this irradiation! In our opinion the results which we have just cited largely suffice to prove this direct action—injurious when it damages the cell but advantageous when it merely excites them.

### EFFECT OF RADIOACTIVITY UPON THE MICROBES OF THE SOIL

As far back as 1912 we made an attempt to explain to the section of plant pathology of the First International Congress of Comparative Pathology, held by the Paris Faculty of Medicine,[9] the probable effect of radioactivity upon the fixation of atmospheric nitrogen and upon nitrification, which are, as we know, the grandiose work of infinitely minute organisms. This idea which seems to us a fertile one and which we believe we ourselves were the first to announce, has made headway since. . . . It should be stated that a note by M. Stoklasa, the director of the Agronomic Station at Prague, was read before the Academy of Sciences a year later, in 1913, giving a description of the experimental study of this theory. The substance of it may be stated as follows:

The well-known ionizing action of radioactive bodies and the moderate ozonization which results therefrom, favor pullulation and the functioning of the nitrifying microbes, which are aerobic in nature. Everywhere in fact where the force of radioactivity is exerted, the milieu is rendered a conductor.

The precise measurements made by the electroscope . . . of slight as well as of strong degrees of activity is justly based upon this phenomenon of ionization, which is always accompanied by the formation of a certain amount of ozone.

But ozone, whose oxidizing power is well known, is in fine merely the oxygen placed at the disposal of the nitrifying or fixating bacteria of atmospheric nitrogen.

The experiments of Stoklasa, which are worth quoting but need to be repeated with a stricter technique, prove that radioactivity acts upon these aerobic microbes in an advantageous manner, as affirmed by ourselves previously. Not only do they profit by the oxygenation of the milieu but perhaps they are likewise capable—why not formulate the hypothesis of utilizing, in their own vital processes and the hypher-functioning a portion of the liberated energy which has been put at their disposal.

However this may be Stoklasa[10] has studied by means of an ingenious technique the influence of radioactivity:

a. Upon the bacteria which fixate nitrogen;

b. Upon the bacteria which transform organic nitrogen leading to ammonia as a final product;

c. Upon the denitrifying bacteria which are in general anaerobic.

Without going further into these researches some of which are made with a rather impure radioactive mineral called nasturan or pitch blend[11] and sometimes, which is much better with the gaseous emanation of radium, we may state that they have enabled us to prove the formation in cultures thus treated and carefully analyzed of a very much larger proportion of nitrogen. In the same way the earth planted with nitro-bacteria is enriched with nitrogen when subjected to radioactive emination.

In our opinion the ozonization provoked by all radioactivity (*i.e.*, the flow of electrified particles of matter) is equivalent

[5] It is to be noted that the energy of the $\beta$ rays is only about 1/100 that of the $\alpha$ rays.

[6] The Nogier *Lyon Médical*, Dec. 7, 1913.

[7] The quantity of emanation produced in 1 mm. by 1 ml. of radium bromide.

[8] *Acad. d. Sc.*, March 17, 1913 (Note presented by Professor Chauveau.

[9] Vide the volumes of Congré (Pub. by Masson).

[10] C. R. Acad. d. Sc., Nov. 10, 1913 (Presented by Professor Maquenne).

[11] Joachims, that pitch blend has an activity of 3.64 compared to that of uranium taken as a unit.

to a sort of permanent and homogeneous aeration of the soil which no other process is capable of accomplishing. Let us remember that certain bacteria whose presence is, indeed, of capital importance—since no plant will develop in earth previously sterilized—are not the only ones to benefit by this treatment. Without speaking further of the territory itself which serves them as a culture medium and within which there take place so many mysterious reactions and oxidations, which may thus be accelerated, there is only one sort of cellular physiology, and oxygen is indispensable to the creation of protoplasms, whether it belong to a man or to a blade of grass! The blood carries to our cells the vivifying oxygen which we breathe, but the plant must be surrounded by it or else it dies. The seed, in particular, which is about to germinate in obscurity encloses a living organism of exquisite delicacy, the embryo. From its differentiation there results first the fragile seedling and then the robust plant into which it splendidly expands. Oxygen supports and exalts the vitality of the embryo as well as that of the roots and the entire plant.

CONCLUSIONS

To sum the matter up the triple radiation ($\alpha$, $\beta$, $\gamma$) with the production of electricity and of heat always exhibited by radioactivity are capable of being of essential service to vegetation.

Moderate-powered irradiations produce a sort of harmless traumatism by means of their gentle but continuous bombardment, and thus undoubtedly exert a direct stimulus upon the plant cells in their path; the phenomena of heat and of electricity in their turn produce profound modifications in the milieu, rendering it more propitious to life, by precipitating the dissociation of organic matters destined to be assimilated; finally, the process of oxygenation is superadded, so to say, with the result of intensifying the vegetative functions while the pullulation of the countless germs present in the ever fecund earth occasion the fixation of atmospheric nitrogen on the one hand and nitrification on the other.

In short it is quite certain that radioactivity is capable of assisting plant life in very great measure. . . . But if it is too feeble it is inoperative, whereas if it is too powerful it is harmful. And herein lies the difficulty.

If we might advise agriculturists we would insist on their making a very careful previous study of those radioactive substances which contain no fertilizing principle within themselves, but which should be added to ordinary fertilizers that the plant may be stimulated as well as nourished.

It is evident that a vast field for experiment is here opened. It has been justly said that the rational application of scientific method ought both to facilitate the cultivation of the soil and to render it more productive.

# Excretion in Plants*

## Flowers, Leaves, Fruit and Bark Regarded as Excretory Organs

By P. C. Van der Wolk

JUST as animals do, plants secrete poisonous products of metabolism which must be rendered harmless. But while the animal excretes these substances and removes himself from their neighborhood, plants suffer the disadvantage of not being gifted with powers of locomotion. It has long been known in agriculture that because of this it is quite possible for plants to perish or to make the ground nonfertile. The appearance of unfruitful zones surrounding plants and trees; the impossibility which exists of plants living too closely side by side; the problem of what is known as "soil fatigue"; the hostility exhibited by certain plants toward given fertilizers; much of the reproach unreasonably ascribed to the physical condition of the ground; the entire question of the rotation of crops—all of these may be regarded as results of the phenomena of excretion in plants, to which too little attention has thus far been devoted, and which will eventually undoubtedly be regarded as lying at the very basis of modern agricultural science. An example indicating what an important rôle may be played by the problem of excretion in the most ordinary operations of gardening and field cultivation, is the observation that the pruning of plants improperly or at the wrong time tends in some inexplicable manner to deprive the ground in which they are grown of its fertility. As a matter of fact, we are here concerned with an actual poisoning of the ground through excretory matters which are forced to make their exit from the plants, through the roots, because the aerial organs of excretion, whose function it is to make the excreted substances harmless, or to get rid of them by evaporating them in the form of gases, *i.e.*, leaves and flowers, fruit and bark, have been ruthlessly cut away: This is the excretion theory of the effect of pruning!

Because of the fact that plants are unable to change their environments at will, the technological questions concerned with their excretion products differ from those concerning the excreta of animals, and on this account a very important feature of the matter is the circumstance that plants are in the habit of transforming many of the injurious products of metabolism secreted by them into gases, which pass into the air and are blown away. Among the gases thus liberated we must include not only carbon dioxide but all those fragrant substances which many flowers and leaves pour forth into the air.

The excretions of plants must be divided into those which are *direct* and those which are *indirect*, the former include those which are directly excluded from the organism, and this is the commonest form of excretion. But plants are also capable of changing products which are originally injurious into other substances which are quite harmless, and even of employing these for constructive purposes. This transformation of a harmful product to a harmless one is an example of *indirect excretion*. We find such products most beautifully exemplified in the *bark*, which in very many cases forms a thick cork-like layer of dead cells around the living body of the plant; this dead layer is continually thrust outward because of the fact that fresh products of metabolism must be rendered innocuous and yet, at the same time, this excreted substance plays an important part as regards the welfare of the plant.

It happens in a great number of cases, too, that the bark still contains toxic substances. The bark of a tree may be compared in general to that coat of armor formed by *chitin*, which encases insects since chitin likewise has its origin in the transformation of products of metabolism.

*Excretions in Fruits.*—An important instance of this sort of indirect excretion is furnished in fruits. The fruit of a plant consists essentially of a sort of storehouse of excretory substances, and it is a well-known fact that it is the fruit especially which constitutes the poisonous organs in a great number of plants, as, for example, the berries of many plants. These poisons include also the acids and tannins which make many fruits unpleasant to the taste. But when in the course of historic evolution this organ of excretion has become united with the organ of reproduction and thus contains the seeds of the plant it often occurs that by means of secondary enzymatic processes a portion of such excreted substances in

*Translated for the *Scientific American Monthly* from *Die Umschau* (Frankfurt), Jan. 29, 1921.

the fruit are transformed into products which are not only harmless, but may be even useful as nutritious substances, such as various kinds of sugars, fats, and albumins. In practical life we are accustomed to designate this sort of transformation as a *process of ripening*. The substances thus produced often serve as a store of nutrition for the use of the embryo and are of service later to the young plant during its germination. But we must not lose sight of the fact—indeed we may especially emphasize the possibility that this formation of sugar is an entirely independent process, whose original purpose was to render harmless the toxic excretion products. It was not until later that the organ of reproduction, *the germ of the future plant* became, united with the fruit, whether by chance or whether *because of the fact* that it found one sort or another of sugar ready for its use.

It is obvious enough that plants which are tied down to a definite location must exercise great care with respect to the getting rid of those excretory substances which they must reject, but which they cannot move away from. At the same time we must remember that this is the very reason why we are commonly unaware that the plant does reject excreted substances. The plant collects its excretion products in its own reservoirs and keeps them there until its period of rest occurs, at which time it gets rid of them. This can be recognized as *true not only in the case of the fruit but also in that of the leaves.*

*The Fall of the Leaf.*—Throughout the entire year and, especially, as autumn comes on, the leaves saturate themselves with substances which we know to be injurious to the life of the plant, and when these leafy reservoirs are filled to the brim the leaf flutters to the ground. The fall of the leaves at the end of the period of vegetation is primarily, indeed, a phenomenon of excretion. In short, *leaves are organs of excretion of prime importance.* And they accomplish their function, not only through transpiration but also by exuding drops of liquid by day, as may be observed in several house plants as well as at the points of blades of grass and along the rims of the leaves of the capucines. These drops contain a solution of various substances undesirable to the plant and sometimes in such great measure that they actually form a crust about the body of the plant. It often happens that excretory products collect in certain cells and are then decomposed by means of a secondary enzymatic process into delightfully fragrant oils, such as those of the orange and the lemon. The same thing holds true for flowers, since essentially speaking flowers and foliage are practically the same. We are willing enough to admit that the flower represents an "*adaptation*" for the purpose of attracting insects, yet it has, nevertheless, retained its essential character, which is the same as that of the leaf, *i.e.*, it is an organ of excretion; it becomes saturated with excretion products which are often cast upon the air in the form of perfumes, and it likewise falls to the ground when its appointed time has come.

With respect to the fact that flower petals are lacking in the function of nutrition because of the absence of chlorophyl, it may be remarked that the flower has developed more markedly than the foliage into a specific organ of excretion. That the flower so quickly loses its hold, as if the plant were glad to get rid of it as soon as possible has, therefore, an excretory significance. And to carry out this sort of "biological process of thinking" we may even regard the allurement of insects and their carrying away of honey and pollen, as being primarily of use to the plant as a means of getting rid of its excretion products, via the maw of the animal. Indeed it is quite possible that it is exactly on this account the plant has arrived, in the course of its history, at the location of its organ of reproduction in the flower, just as we have remarked with respect to the fruit. In this organ, too, it may be assumed that in *the beginning* this attraction of animals was meant to secure a carrying away from its own neighborhood of the harmful products excreted by the plant.

## A NEW OIL PLANT FROM THE CONGO

By J. PIERAERTS

THE curator of the Museum of the Belgian Congo has recently announced his study of the seeds of a new oil bearing plant, which promises to be very valuable since the kernels contain over 47 per cent of fatty matters, yielding an oil which much resembles olive oil, being odorless, pleasant of taste, and non-siccative and producing with soda a very attractive light colored soap. According to M. Pieraerts (*Bull. d. Sci. pharm.*, Oct., 1920). The plant which bears this seed is an immense vine or liana of great strength, but at the same time very ornamental because of its rich foliage and large flowers. A marked feature of its growth is the production of an enormous tubercle, weighing from 10 kg. to 40 kg. This tubercle is very rich in starch, but it is reputed to be poisonous.

Further experiments will be made to determine whether the oil and the oil cake are likewise poisonous, and if this is the case, whether the toxic quality can be removed, which is done in many other instances as in the case of the manioc root from which tapioca is prepared. It is to be hoped that this can be done since besides the high percentage of oil the residual cake contains more than 19 per cent of nitrogenous substances. In any case, however, the oil will undoubtedly prove valuable for various industrial purposes.

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## THE PSEUDO-MIRACLE OF BLOODY SWEAT

THE red colored perspiration, vulgarly known as "bloody sweat" is so striking a phenomenon that it was not unnaturally regarded in the Middle Ages as being of miracular origin. It sometimes makes its appearance on the skin of individuals suffering from over-fatigue or strong excitement and this would lend color, of course, to belief that the red color was really due to blood oozing through the skin. It was not until the existence of micro-organisms was demonstrated that science was able to discover the real explanation of this curious phenomenon. It is due, as a matter of fact, to certain minute living organisms which attack the human body and form thriving colonies in areas where there is much perspiration given off. These colonies are held together by a sort of mucus and since they are red in color this mucus has the appearance of drops of blood. This affliction is not specially injurious and can easily be remedied by washing the parts affected with soap and water and then applying a reliable germicide.

A close relative of this perspiration bacillus is responsible for the red dots which sometimes make their appearance on foodstuffs, such as bread, eggs, and milk, and gradually extend their area until the material is stained with "bloody" spots and stripes. It was the German naturalist, Herenberg, who first discovered that these spots of "blood" did not have their origin in a miracle, as was supposed by the credulous, but in a small organism called by him "the miracle monad" (*Monas prodigioso*).

In the Middle Ages this strange and peculiar phenomenon was thought to be the work of witches and other persons who had sold their souls to the devil, and many a poor wretch was persecuted as a supposed perpetrator of this defilement of food.

This sort of "blood" is sometimes found in ponds or on the ground, and this accounts for the so-called "bloody" rain sometimes seen, which was formerly thought to be a monstrous portent of coming evil. We now know that bacteria are responsible for all these strange occurrences. Millions of these minute organisms are occupied in the decomposition of the débris of plants and animals in water and on damp soil. Some of these are white, green, or yellow in color and, therefore, make but little impression on the eye even when present in large masses; but when they happen to be pale or dark red or brownish in color, they at once suggest to the eye of the ignorant an evil omen.—Translated for the *Scientific American Monthly* from *Ueber Land und Meer* (Berlin).

# Laying the Dust with Fog

## The "Nebulizer"—A Device for Artificially Producing Mist

By Donovan McClure

THERE is considerable difficulty in producing a satisfactory artificial mist, since most of the devices employed to reduce water to a state of fine division, merely produce a fine rain which soon falls to the ground. The problem is one of considerable practical importance; not only do scientists employ such fogs in the study of various problems but one of the most recent hygienic measures recommended for use in the so-called dusty trades consists in the formation of such a mist in which the particles of water gather to themselves the floating dust in the air. By taking the proper measures this mist can then be precipitated carrying down with it the foreign matter which is so injurious to the lungs of the workmen. It is well known that the rate of tuberculosis is very high among bakers, millers, workmen in textile factories, and other operatives engaged in trades where the atmosphere is filled with fine particles of suspended matter. Some recent experiments by an Italian physician, Dr. L. V. Nicolai, a professor at the University of Pavia, have led to the hope that this means of purifying the air without creating draughts and without merely blowing the dust from one area to another may be generally employed. Dr. Nicolai calls his process "nebulization" and it consists in the production of artificial fogs and their application to various hygienic, medical and industrial purposes.

Dr. Nicolai is a specialist in diseases of the ear, nose, and throat, and has, therefore, been attracted by the problem of causing curative agents to penetrate as far as possible into the respiratory passages. Being dissatisfied with the various atomizers of liquids already on the market, he set himself to the task of producing a better one, which he accomplished by using a Giffard injector in an inverse direction.

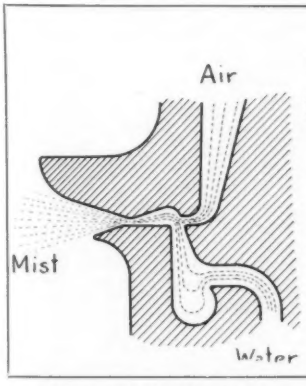



FIG. 1. DIAGRAM ILLUSTRATING THE PROCESS OF NEBULIZATION

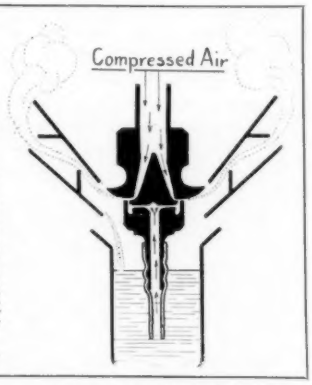



FIG. 2. OPERATIVE PRINCIPLE OF THE APPARATUS

Giffard injectors, Bunsen blow pipes and ordinary atomizers are based upon the principle of a fluid which draws along another fluid by means of the aspiration produced by the falling of liquids in capillary tubes. In some atomizers the two conducting tubes form an angle which may be as great as 90 deg. The sprays of droplets produced by such apparatus are always divergent along the cone of an angle which is more or less acute. As a result of this fact there is a great range of size among the drops which make their exit at the same time, since some of the drops run together to form larger ones. In fact the spray issuing from the ordinary atomizer is heterogeneous in nature and somewhat indefinite as to its character.

In Dr. Nicolai's device, on the contrary, the droplets are extremely tenuous and are produced without any complicated apparatus such as is required in those apparatus which make use of capillary tubes through which it is impossible to force liquids effectively except by means of strong pressure.

In the Nicolai instrument the liquids are drawn up by the barometric depression which is produced by the flowing of a current of air under 3 kilograms of pressure, and this flow is effected in a horizontal plane in a circular and radiating movement over as large a surface as possible. Furthermore, the space limiting the passage of the fluids can be regulated at will in order to obtain the best results.

The stratum of spray thus produced can be projected directly into the atmosphere if desired, but in this instrument a double walled bell jar in the form of a funnel is interposed. The selective effect thus produced is increased by the use of staggered baffles upon which the larger particles of fluid strike and break.

By this means a very fine mist-like spray is ejected from the ring-shaped orifice at the top of the apparatus. The intensity of this artificial mist is proportionate to the yield and its degree of opacity depends upon the density of the liquid employed.

Various investigators have produced artificial fogs for purposes of study, Salies de Béarn, among others, and have found that with saline solutions registering 5 deg. B. the fog produced soon becomes sufficiently opaque to absorb the radiation of a 50-candlepower lamp at a distance of 1½ meters. The "nebulized" fog produced by Dr. Nicolai's apparatus consists of liquid particles of from 1 to 5 microns in diameter; it spreads in any atmosphere whatever, sharing in the eddies produced in the air either by variations of temperature or by the sweeping movement produced by the arrangement of the apparatus. It flows along the walls, rising and falling, and homogenizing the atmosphere and it takes several hours to settle. This nebulized fog carries electric charges of the same size which tend to repel each other and thus prevent condensation, which is a very important point as regards its persistence. Because of its extreme fineness it penetrates all the interstices of fabrics, furs, tapestries, etc., without making them damp. For this reason it serves admirably for producing humidity in dusty factories or work rooms. Furthermore it may be made the medium for bearing healing agents, such as balsam, saline, salts, etc., which it will distribute in a very homogeneous manner.

### ARTIFICIAL FOG UNDER THE MICROSCOPE

When examined under the microscope this fog exhibits the form of a mass of spherical droplets, whose diameter indicates that they possess a very high superficial tension. These infinitesimal corpuscles are naturally so light in weight that the resistance offered them by the air almost overcomes the force of gravity. It is assumed that natural fogs require the presence of a nucleus of condensation as one of the conditions of their production. The nebulized saline solutions behave in the same manner as natural fogs, but when perfectly pure water is nebulized the fog produced is considerably less opaque. It is because of this greater degree of transparency that this process of nebulization can be used to purify auditoriums, laboratories, and work rooms without disturbing the atmosphere.

In studying fogs thus produced, Dr. Nicolai found that the opacity of the fog increases with the temperature and that by cooling the fog, it can be rendered transparent. Moreover he found that increasing or diminishing the pressure does not alter the structure of the fog, which when brought back to

ordinary atmospheric pressure perceptibly resumes its initial condition; the lowering of the temperature occasions a deposit of drops of dew on the walls which is in accordance with the theory.

Because of the extremely fine state of division of liquids thus secured the latter are able to penetrate all cavities as readily as the air which bears them, and this renders them applicable for giving medical treatment to the natural cavities of the body such as the respiratory passages, the auditory canal, etc. A very great advantage, too, is that this treatment can be given every individual in a room, which adapts it for use in wards of hospitals as well as for private patients. In the same way, too, school children can be subjected to such treatment during their hours of recess, or in study rooms, or in gymnasiums, receiving the healing fog without even realizing its presence.

There are certain mineral waters which are very beneficial in cases of catarrh, influenza, scrofula, etc., and these can be readily nebulized and applied in this form. Another advantage is that the apparatus may be so arranged as to yield a warm fog and, therefore, the healing compound can be supplied to the patient at the temperature of the body, which tends to suppress irritation, facilitate secretion, and reduce œdemas.

A desirable feature of the apparatus is the possibility of attaining any degree of humidity desired without injuring the respiratory organs of persons who are obliged to stay in rooms where humidity is necessary, such for example as the textile industry.

DISINFECTION

Disinfection tests made by the inventor prove that all pathogenic germ not only in the atmosphere but in fabrics

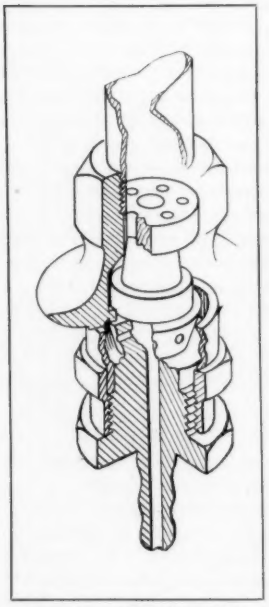


FIG. 3. CONSTRUCTIONAL DETAILS OF THE NEBULIZER

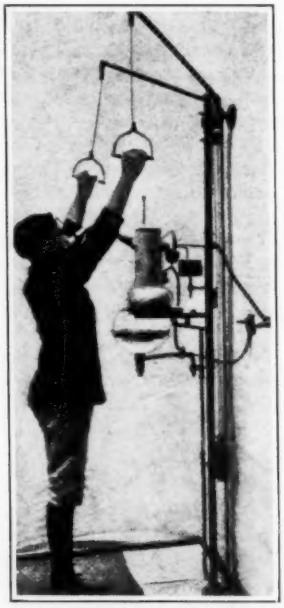


FIG. 4. NEBULIZER USED FOR INDIVIDUAL INHALATION

and furs, books and papers, etc., can be completely sterilized in five to twelve hours, even where there are several thicknesses of cloth or paper. It was even found that mattresses and pillows badly soiled by infectious discharges, could be thoroughly disinfected provided a comparative vacuum was produced before the beginning of the nebulization process. This finding makes obvious the value of the process in hospitals, since even bandages and instruments can be completely sterilized by its use.

A definite degree of humidity is required in work rooms where the fibers of cotton or linen are spun or woven. Thanks to the nebulizer the atmosphere may be made humid enough to prevent the fraying of the fibers while at the same time it remains perfectly respirable.

A very interesting point brought out by Dr. Nicolaï is the conclusion to which he came that the nebulized fog probably behaves in the same manner as the high frequency currents

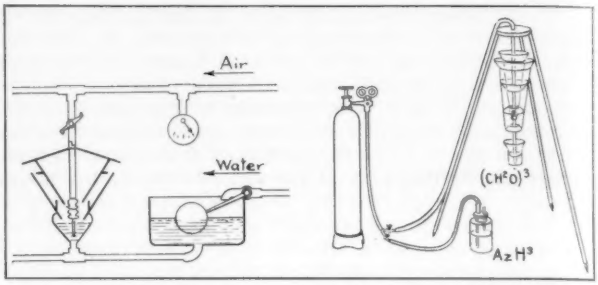



FIG. 5. USING THE NEBULIZER TO HUMIDIFY THE AIR




FIG. 6. THE NEBULIZER DISTRIBUTING DISINFECTANTS

with which some investigators have sought to obtain the same end. Not only the textile industries but those which manufacture powders and chemical products frequently require a definite degree of humidity for one reason or another—for manipulation, combination, or conservation, and in all these cases the new process is advisable.

We have already spoken of the production of medicated fogs for use in schools, hospitals, auditoriums, etc., where numbers of persons can be treated at the same time at comparatively small expense. It may be added that instead of this humidification of an entire room the healing fog may be produced by means of an inhaler at the entrance of the respiratory passages of an individual. A great many instances will suggest themselves where animals attacked by microbic or cryptogamic diseases can be successfully treated in this manner, as may also many plants suffering from diseases due to harmful fungi, etc.

Even the best carburetors used at present in explosion motors occasion a good deal of waste of fuel because of the imperfect mixtures they produce. It is claimed that this apparatus produces a much more intimate and therefore successful mixture of the combustible (under pressure) with the carburizer and, therefore, effects considerable saving. The apparatus can be so modified also as to perform the same service in oil burning engines. The inventor is already testing various forms of construction to discover the best form for nebulizing light oils, on the one hand, and heavy oils on the other. Another application is in the dairy industry where it can be used to produce a state of fine division in the fatty elements of milk, so that they may be the better held in a state of suspension.

## SEALING GLASS WITH OPTICALLY FINISHED SURFACES

FOR the purpose of making pyrometer lamps with plane sides, a method of sealing a glass plate with optically finished surfaces to a tube was developed. The process consists essentially in heating the parts in a suitable furnace to a temperature determined by the annealing characteristics of the glasses to be joined, and then making the seal by applying a very small flame to the joint, the heating being localized so that the finished surfaces are not distorted except for a very small portion at the joint. The method has been applied to the making of various kinds of cells used in optical work and represents a distinct advance in the technique of the manufacture of such apparatus. A paper describing the method and showing some of the results obtained has been published in the *Journal of the Optical Society of America*.

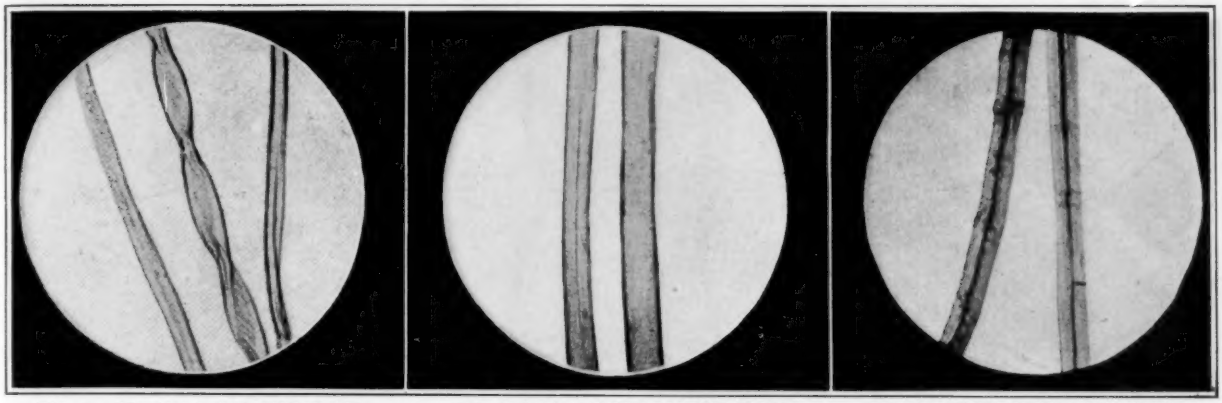


FIG. 1. COTTON FIBER ENLARGED 160 DIAMETERS
Note the "twisted ribbon" appearance of the middle fiber

FIG. 2. MERCERIZED COTTON, X 160 DIAMETERS
Fibers untwisted under tension in a hot caustic soda solution

FIG. 3. FLAX FIBERS ENLARGED 120 DIAMETERS
Note the "bamboo-like" appearance due to the jointed structure

# Textile Fibers*

## Nature of the Fibers and Tests for Their Identification

By Harvey G. Elledge and Alice L. Wakefield
Industrial Fellows of the Mellon Institute of Industrial Research

THE records obtained by archeologists dating back as far as 2600 B. C. show the arts of spinning and weaving to have been in a late stage of development at that time. Beyond that date nothing definite is known because no records have been found; in fact, no records are expected of the very earliest stages since these arts appeared long before man began to express himself by means of writing.

However, from our present knowledge of man and the progress of his ideas and intellect from infancy to manhood, it has been possible to imagine the first steps taken by primitive man in the evolution of the art of cloth manufacture. When the first desire or need for body covering arose, our ancestors took what lay nearest at hand and clothed themselves with the robes which nature had furnished their less highly endowed brothers, the four-footed, fur-bearing animals. To do this, implements for obtaining the skins were necessary, and the cleverness displayed in their preparation soon found expression in another way. Rushes and fibrous grasses were plaited or woven into mats that were found to be much lighter and more suitable for purposes of clothing in certain climates and seasons than were the animal skins.

Continued use of the grasses demonstrated that an exceedingly wide field of application of heretofore useless materials had been opened to ingenious minds. Experience proved that for purposes of covering or decorating the body some plants were more desirable than others. The desirable features of these plants were found to be confined to one section of the stalk, the section lying between the bark and the woody portion; these features were toughness, pliability and greater ease of bleaching. Primitive man was even more prone to personal decoration than civilized man and early realized that white cloth gave him clearer and more brilliant colors than gray or cream cloth did. The fibers that resulted from the manipulation of rushes and reeds by the ancients are the linen fibers of today, and by virtue of their descent from reed weaving, and the fact that reed weaving goes back beyond any other type of weaving, linen fibers may be called the oldest of the textile fibers.

Long after grass fibers were first used, but before their use had reached any great degree of perfection, the possession of herds had brought a knowledge of wool. Wool originally did duty as a body covering in the natural form of an unclipped skin, and the real value of wool fibers became apparent only after the discovery was made (by accident rather than by intent) that by simultaneously pulling and twisting the clipped wool a long continuous strand could be obtained. This process of pulling and twisting (later called spinning) was quickly applied to other fibers, and, by means of it, many fibers, hitherto useless for weaving, by reason of their extreme shortness, were added to the list of useful natural products. Cotton was the most important of these later additions, but, like silk, was not used extensively for a long period and was regarded as a rare luxury. Today, however, the relative economic values have changed so that cotton heads the list as the one fiber used most universally and in largest quantity, while linen, wool and silk take their places in the order named.

It is interesting to note that these four fibers, known now for ages, still remain the best and most useful aids to man's physical comfort. They are grouped as vegetable fibers (cotton and linen) and animal fibers (wool and silk), on account of the sources from which they are derived. The vegetable fibers are further differentiated as seed and bast fibers; *i.e.*, fibers from the seed pod and fibers from that portion of the stalk known as the bast region, lying between the outer bark and the inner woody portion.

### COTTON

This fiber (which is useful only when ripe) belongs to the class of seed fibers and is disclosed in the ripe burst seed pod as numerous white hairs or fibers attached to the seeds. Before spinning, these fibers must be removed from the seed and, previous to the invention of the cotton gin by Eli Whitney, this was done by hand. Microscopic examination shows the individual fiber to be a long, slender, flat tube, spirally twisted about its axis. Fig. 1 is a photomicrograph (a photograph taken through a high power microscope) of cotton showing the details of its structure. One end will be found closed and pointed; this is the loose end of the fiber as it grew within

*Abstracted from "The Conservation of Textiles," by Harvey G. Elledge and Alice L. Wakefield, by permission of the publishers—The Laundryowners National Association.

[1]Fig. 1 is copied from the "Encyclopedia Britannica." Figs. 2, 5 and 6 from "A Manual of Dyeing," by Knecht, Rawson and Loewenthal: Figs. 3 and 4 from "A Manual of Modern Steam Laundry Work," by E. Clayton.

FIG. 4. WOOL FIBERS ENLARGED 120 DIAMETERS
Note the overlapping scales that characterize wool fiber

FIG. 5. "BOILED-OFF" SILK, X 100 DIAMETERS
The gum has been boiled off, revealing the glossy fibers themselves

FIG. 6. RAW SILK ENLARGED 60 DIAMETERS
Each strand is really two fibers covered with a coating of gum

the seed pod. The other end will be found blunt and ragged where it has been torn from the seed. The fibers vary considerably both in length and width, the longer ones being best suited for spinning and weaving because when spun greater intertwining of the individual fibers occurs, resulting in a yarn of greater strength than that spun from shorter fibers. Actual measurements show the variation in length of the fibers to be, on the average, from eight-tenths of an inch to one and eight-tenths inches, although some fibers come as short as one-half inch. These extremely short fibers are usually combined with longer fibers to insure for the finished yarn a reasonable tensile strength. Such is not always the case, however, and many damages exhibited by fabrics are the direct result of the use of these short fibers alone, without the reinforcement of a percentage of longer fibers.

*Mercerized Cotton.*—A variation of the natural cotton is mercerized cotton. The difference between the two is physical rather than chemical, although it is brought about through the action of caustic soda. Mercerization causes the fiber to become transparent and to lose its flat spiral form to become a nearly straight cylinder having an increased power of light reflection and consequently a higher gloss. This change in form is illustrated by Fig. 2. The mercerized fiber is even stronger than the raw fiber when the conditions of mercerization have been carefully guarded and overtreatment avoided. The only part of the change that is apparent to the eye, unaided by a magnifying instrument, is the increased gloss.

*Schreiner Finish for Cotton.*—A high luster, similar to that appearing on mercerized cotton, can be given to a piece of cotton cloth by subjecting it to a process called calendering. This process consists of passing the cloth between rollers under heavy pressure. One of the rolls is engraved with obliquely set lines, ruled from 125 to 600 to the inch; these lines produce a great number of parallel, flat surfaces on the cloth, which cause it to acquire a high luster. If the rollers are heated during the process, a finish is produced that closely resembles mercerized cotton, and is quite permanent. This finish, however, is lost to a large degree on washing.

### LINEN

Linen is a representative of the bast fibers and is obtained by fermentation of the whole flax plant. This process prepares those parts of the stalk that are undesirable as textile fibers so that further treatment by drying and rolling removes them, leaving the long tough fibers to be used for spinning. When examined microscopically (see Fig. 3), a linen fiber presents a more or less bamboo-like structure, caused by the occurrence of several cells in sequence, with nodes or knots at irregular intervals where two cells are joined at the ends. An individual cell measures in length from twenty to forty millimeters (7/100 to 15/100 of an inch); consequently the long fibers of combed flax linen consist of a large number of cells attached end to end. These fibers, by virtue of their greater length, furnish a much stronger yarn than does cotton.

### WOOL

Wool and silk, though grouped together as animal fibers, are produced in entirely different ways. The term wool is usually taken to mean the hair of the sheep, although the hair of certain goats (Cashmere, Mohair, etc.) and of the camel are classed under the same name. The kind of animal from which it is obtained and the location on the body determine the quality characteristics of the wool, which may be short or long, coarse or fine, dull or lustrous. A long stapled wool fiber is one that measures over one and one-half inches in length, and its diameter is usually proportional to its length. Long stapled wool is generally combed and spun into worsted yarn and used for the best qualities of coatings, dress goods, etc., while the short fibers are carded and spun into woolen yarn, which is subjected to a fulling process subsequent to being woven into fabrics, in order to impart thicker and fuller feel to the fabric.

A close microscopical examination of wool reveals a cylindrical fiber covered with flattened, horny scales, which are funnel-like and which overlap each other in the manner of fish scales (see Fig. 4). The dimensions, uniformity and compactness of these scales are generally conceded to determine the luster and strength of the wool.

Wool differs from the vegetable fibers in several important respects. It possesses greater elasticity and strength and is more lustrous; it is curly and has the property of becoming felted under certain conditions, which are outlined in the L. N. A. charts of Standard Procedure for Washroom Practice as including the use of too low a bath with too little soap. This property, while being useful in certain ways, is a nuisance in others, and it is well for launderers to keep this fact in mind when handling woolen articles. The exact physical change that takes place during the process of felting is still under discussion, but experiments carried out by the Department of Chemical Engineering of the Laundryowners National Association have proved that it is the result of hard pounding in the wheel rather than of changes in temperature, which was first given as the cause of the phenomenon and was said to cause contraction of the fiber and an interlocking of the scales. The observation made by this Department upon the cause of felting is substantiated by the research findings of the United States Government workers on this problem.[2]

### SILK

Silk is a substance secreted by several species of caterpillar

[2]A full report of the work is to be found in the laundry trade journals for the early part of 1919.

for the purpose of forming a cocoon in which the change from the caterpillar stage to the moth stage of existence occurs. It is produced by two glands, situated one on each side of the body, and is carried by ducts to the head of the caterpillar where the spinneret is located. Here on coming in contact with the air the two gelatinous streams solidify and are cemented together by another secretion which is produced by glands located near the spinneret. While all caterpillars spin cocoons in this manner, the secretions of only a few species form strands of sufficient strength to make them of value as textile fibers. When recovering these fibers for spinning, the cocoons are placed in water at a temperature of 60° C. to soften the cement which binds the two fibers together. When this softening has taken place the fibers are reeled on spools, several strands being reeled together to form a thread.

Raw silk (unreeled silk or the cocoon proper) is of a creamy or yellowish color and has very little luster. When examined under the microscope it appears as two straight, transparent fibers, absolutely lacking in cellular structure, cemented together along their whole length (Fig. 6). When boiled with soap solution, the outer layer of cement is removed, and the true luster of the fiber is revealed (Fig. 5). A silk fiber varies from 500 to 1,500 yards in length and in diameter from 0.01 to 0.02 millimeters (4/1000 to 8/1000 inch). Besides the advantage afforded by such exceptional length, silk is extremely elastic and is the strongest and most lustrous of the natural fibers. The best silk is produced by silk-worms reared under artificial environment and carefully cultivated, and is finer, whiter and more lustrous than the so-called "wild" silks obtained from the cocoons of uncultivated worms.

*Artificial Silk.*—The demand for silk has reached such proportions that efforts to supply its beauty at a popular price have led to the manufacture of artificial silks. The most important varieties of these fibers are prepared by the same fundamental formula, which calls for a solution of some chemical product of cellulose in an appropriate liquid. Of the two types of artificial silk on the market, the better known is made from cellulose hydrate, more commonly called viscose. The other type is manufactured from cellulose acetate, and sold under the trade-name of "Lustron." Viscose and cellulose acetate "silks" differ materially, chemically, but the physical differences are not marked. However, the identification of the type to which an artificial silk belongs may be readily accomplished in the laboratory.

The process of manufacture of artificial silk is briefly as follows: A solution of viscose (or of cellulose acetate) in a suitable solvent and of desired concentration is extruded by appropriate mechanical devices in such a way as to convert the viscous solution into filament form. These filaments or threads are placed into some medium that causes immediate coagulation or hardening, and are reeled from this coagulating material and prepared for weaving in the same manner as silk, *per se*. None of the varieties of cellulose silk possesses the strength and elasticity of real silk nor its resistance to the process of washing; they all have to be handled with considerable care and even with such treatment the results obtained are often not entirely satisfactory.

This product of the chemical laboratory can hardly be differentiated from real silk by microscopical examination because of the absolute lack of physical characteristics that exists in both types of fiber; it happens, however, that the one physical point of difference lies in the greater luster of the artificial silk, which shows such an increase over that of real silk that identification can be made merely from an inspection of the fabrics. In case any doubt remains in the mind of the inspector recourse may be had to simple chemical tests that are infallible.

### TESTS FOR THE IDENTIFICATION OF FIBERS

*Differentiation of Artificial and True Silk.*—The simplest of these tests is burning and identifying the odor that results; an odor as of burning feathers indicates real silk, an odor as of burning wood indicates artificial silk. Another test, that improves on this test by replacing the factor of personal judgment with one of purely chemical character, is conducted by heating a portion of the fibers under examination in a dry test tube and testing the reaction of the volatile matter driven off by this treatment with a piece of moist neutral litmus paper placed at the mouth of the test tube. If the litmus paper becomes red, the fumes are acid and prove the fibers to be artificial silk; if the litmus paper becomes blue, the fumes are alkaline with ammonia and prove the fibers to be real silk.

These are two of the few reliable tests recommended for the identification of textile fibers. Textile literature is filled with tests that are said to be good and that have been praised beyond their actual merits. It is often quite possible that these tests deserve their reputation for great delicacy of indication, provided we consider one important factor, *i.e.*, the relation of the manipulator to the results. If the delicay of the test is greater than the degree of delicacy of technic that lies within the possibilities of the average manipulator, the chances are that the test will fail when applied by other than the man who has worked it out. The process of evolution has gained for the originator of the test a knowledge of

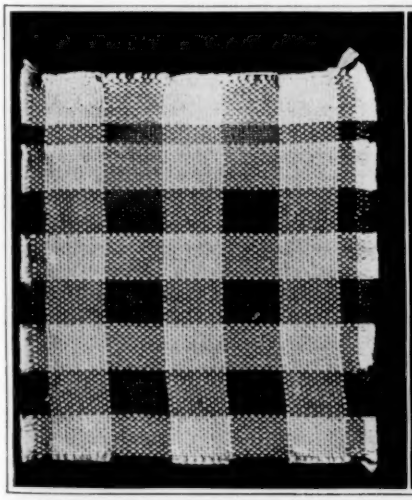


FIG. 7. A WOOL AND COTTON MIXTURE, THE WOOL DYED DARK

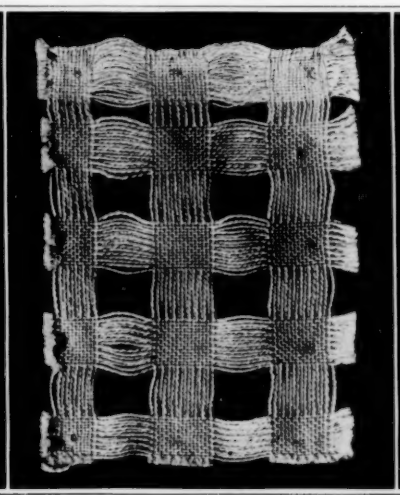


FIG. 8. COTTON THAT HAS SURVIVED TREATMENT WITH CAUSTIC SODA

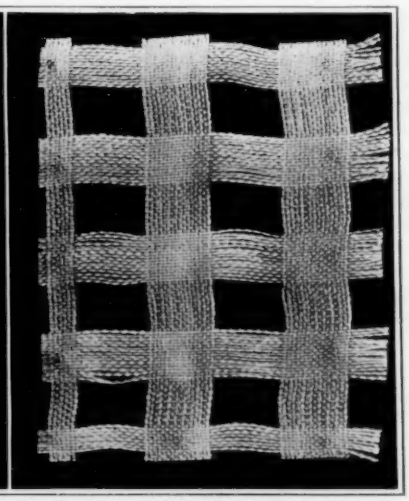


FIG. 9. WOOL THAT HAS SURVIVED TREATMENT WITH SULFURIC ACID

the reactions involved and a fineness of technic that is denied to others who may attempt to use it. It is deemed advisable to include in this chapter a discussion of the tests that have the full endorsement of the authors.

*Tests for Vegetable Fibers in Mixtures.*—If the presence of cotton or linen is suspected in a wool or silk fabric, proof can be obtained by boiling a small piece of the cloth in a 5 per cent solution of caustic soda for five minutes. At the end of this period the wool or silk will be entirely dissolved and any cotton or linen that may be present will remain unaffected by this treatment.

*Tests for Animal Fibers.*—If, on the other hand, it is desired to remove the cotton or linen and leave the wool or silk, the cloth may be saturated with a 2 per cent solution of sulphuric acid ($H_2SO_4$) and then dried in an oven at 100° C. for an hour. This treatment chars cotton and linen fibers and they can be readily removed by rubbing the cloth gently between the palms of the hands. The wool and silk successfully resist the action of the acid. These tests may be made quantitative by using weighed samples, carefully washing, drying and weighing the residue. The weight of the residue divided by the weight of the sample and multiplied by 100 equals the percentage of wool or silk in the case of treatment with sulphuric acid, and of cotton or linen in the case of treatment with caustic soda. Figs. 7, 8, and 9 illustrate the application of these treatments to a fabric of cotton and wool mixture. Fig. 7 shows a piece of the whole cloth that has been dyed with an acid dye and later bleached to differentiate between the cotton and the wool. The cotton is bleached white while the wool retains its color. Fig. 8 shows the cotton threads that have resisted the action of boiling caustic solution, the open spaces having been occupied by the wool that was dissolved out by this treatment. Fig. 9 shows the condition of the fabric after treatment with sulfuric acid, and presents the unaffected wool fibers with the cotton removed.

It is possible to differentiate between the two animal fibers by chemical analysis, but the procedure is too complex and the apparatus required too bulky to be at the command of everyone. There is no chemical means of differentiating between the vegetable fibers in spite of the oft-repeated statement that such differentiation may be made by treating a mixed cotton and linen cloth with concentrated sulfuric acid for one or two minutes, drying and washing. The statement is made that the linen will survive this treatment while the cotton will not. The degree of solubility of cotton in sulfuric acid approximates that of linen too closely to permit a separation by this method. For these reasons, in cases that prove difficult to decide, it is often desirable to conduct final tests with the microscope.

Although the examination of a fiber with the microscope is the quickest and most reliable method of identifying it, there are times when the microscope is inaccessible and when we must be prepared to recognize fibers from their characteristic appearance when spun and woven into fabrics. The characteristic appearance of the four fibers considered here, as observed without chemical or physical aids, are distinct, yet the best way to acquire a knowledge of their differences is to obtain pieces of material, pick them apart, feel them, and examine them closely for distinguishing features. There are certain statements which can be incorporated into such a book as this, like the fact that mercerized cotton is glossier than natural cotton, and that silk is glossier than either natural or mercerized cotton; that linen has a gloss, but that it is not so hard or high as that of silk or even mercerized cotton; that wool is crinkly and elastic, etc. But what we cannot do is to describe accurately the difference between the several glosses or between the crinkle due to the nature of the wool fiber and that which is acquired in the fabric as the result of the strain exerted by the crossed threads, so that the reader may judge all cases unerringly. There are things that the eye can perceive quickly and the mind retain readily, but which are difficult of description.

## TEMPERATURE AND HUMIDITY IN STORAGE OF EGGS AND CANDY

By Owen T. Lay

Early in 1918 the writer was requested by the manager of one of the largest and most modern cold storage plants in Chicago to assist in an investigation of aqueous vapor in its relation to certain cold storage problems, especially in the storage of eggs.

In order to preserve eggs fresh successfully it is of course necessary for them to be so handled that the life germ (in those that are fertile) is kept dormant, this generally being accomplished by providing a uniform temperature slightly above their freezing point, which is near 28° but varies somewhat with the time of year when laid; and at the same time, keeping the air in the storage room pure, with just the right amount of well diffused water vapor. If the relative humidity is too low the interior moisture of the egg will escape, resulting in a loss in weight and a product that must be placed on the market at a loss as "shrunken"; while, on the other hand, if a high relative humidity obtains for any considerable period mold will form on the cases, fillers, and eggs and affect the flavor seriously.

Throughout the first season, closing in January, 1919, humidity inspections were made bi-weekly in eight rooms, containing approximately 20,000 cases each, it being found that in these heavily insulated rooms which were kept sealed almost constantly, the temperature could be held within 0.5° of the desired degree and the relative humidity held quite constant, although tending to increase gradually as the season advanced. To combat this increase varying quantities of unslaked lime were introduced and at times calcium chloride boxes were used in conjunction with electric fans. However, it was learned that the arbitrary standard of about 88 per cent for the relative humidity was too high, this percentage having been thought about right by many experienced cold storage men; hence, readjustment to a lower percentage was found advisable for the second season, which extended from May, 1919, to January, 1920.

During the second season 14 rooms in the same plant, containing about 250,000 cases, were inspected weekly. Through study of the data gathered during the preceding season, much more desirable results were secured; while, during the third season, closing with January, 1921, the work was expanded to include four storage houses, with about 600,000 cases of eggs and 10,000,000 pounds of candy. The candy included chocolate creams, chocolate nut bars, caramels, hard candies, etc., two ozone machines being used occasionally in keeping the air clean. Most kinds of candy keep best in a dry room, with moderate temperature.

Thanks to the zealous care of those in charge of the mechanical side of the cold storage houses, the practical experience of the superintendents and some of the temperature control men, who now have a basis of carefully compiled data for their own building, reports indicate that the season now closing has been remarkably successful, no complaints have been made, although some of the eggs have been held eight or more months and some of the candy for a year.

It has been found that sling psychrometer readings are the most practical method of finding the relative humidity in different portions of the rooms, a special cold storage instrument graduated to tenths of degrees being very convenient, as well as exact, if carefully used. However, this instrument is intended only for readings of 40° or lower and cannot be used in some candy storage rooms. Graphs are prepared for each room to show the progressive trend of temperature and humidity, temperature readings being taken every four to six hours. At the time the product goes out of storage the factors influencing its condition are plotted for comparison with the ideal sought.

The firm for which this line of work was undertaken is now reconstructing a large warehouse so that the factors of temperature, humidity, and air circulation may be absolutely controlled mechanically.—*Monthly Weather Review*, Dec., 1920.

# Stainless Steel*

## Non-Corrodible Properties of Steel Alloyed With Chromium

By J. H. G. Moneypenny

THE commercial utilization of the non-corrodible properties of steel containing about 12 per cent of chromium may be regarded as one of the outstanding events in the metallurgical world during the past decade. Steel, the most widely-used metal, unfortunately corrodes rather easily, and great precautions have to be taken to protect it, especially in exposed positions. This is particularly noticeable in such large engineering structures as the great railway bridges over the Forth and Tay, where painting is going on practically continuously. The production of a type of steel possessing great resistance to corrosion has obviously a great future, and one may safely say that, as yet, only the fringe of the possibilities has been touched.

Stainless[1] steel contains essentially 11 to 14 per cent of chromium and, for most purposes, not more than about 0.45 per cent of carbon. It frequently contains small amounts of nickel, say up to 1 per cent, but this element has no beneficial effect on the non-corrodible properties, while its presence, if unsuspected, may cause trouble in the heat treatment of the steel, since it has quite a considerable effect on the position of the critical ranges of the steel.

From a microscopic point of view, high-chromium steels, such as stainless, have a great deal of interest. Chromium has the effect of lowering the eutectoid composition in steel to a considerable extent. Whereas in ordinary steel about 0.9 per cent carbon is required to produce a structure consisting entirely of pearlite, with 12 per cent chromium, the same effect is produced with approximately 0.3 per cent carbon. Free carbide or cementite appears when the carbon exceeds this amount. In these steels, also, only part of the carbide forming the pearlite goes into solution at the lower critical temperature change on heating (Ac1), the rest dissolving progressively over a range of some 200°.

The state of combination of the sulphur in these steels requires further investigation. This element is only evolved to a very small extent as sulphuretted hydrogen on dissolving the steel in acids. The evolution method cannot be applied for its estimation, neither can one obtain an ordinary sulphur print on bromide paper. For example, a steel containing 0.07 per cent sulphur only gave a very faint print even after 15 minutes' contact with bromide paper soaked in 10 per cent hydrochloric acid or 15 per cent sulphuric acid. The print obtained was different in type from an ordinary sulphur print in that the impression did not consist of a series of dots but rather of a uniform stain. Evidently the sulphur does not exist as separate particles of either iron or manganese sulphide disseminated through the mass of the steel; apparently it exists in solid solution.

Thermally, the effect of the chromium is to raise the temperature at which the critical ranges occur. The Ac1 point occurs in the range 800°—830° C., and on cooling sufficiently slowly to prevent any hardening effects, the critical temperature change on cooling (Ar1) is found at about 750° C.

Stainless steel possesses notable air-hardening properties. A sample one inch or so in diameter, if allowed to cool freely in the air from 900° C., will have a Brinell hardness number of the order of 500. The capacity of the steel to harden increases with the temperature to which it is heated. In other words, the speed of cooling necessary to harden the steel becomes slower as the temperature to which it is heated rises (providing the latter is, of course, above the carbon change-point); also, slower rates of cooling are necessary to soften or anneal the steel when cooled from progressively higher temperatures.

The property of air-hardening is very useful in a steel. Apart from the obvious fact that less drastic methods of quenching are required (with the attendant lessened danger of cracks, warping, or other undesirable attributes of water-quenching), the slower rate of cooling necessary to harden the steel permits samples of large section to be hardened throughout. It also lessens the danger of soft spots due to retarded quenching. Anyone who has had experience in producing a glass-hard surface over a considerable area in an article made of ordinary carbon steel will appreciate the meaning of the last sentence. Owing to its air-hardening properties, however, the steel requires care during the course of manufacture. Billets, bars, forgings, or stampings are usually heated to at least 1000° C. before any operations are carried out, and if the material after being worked is allowed to cool down on the shop floor it will, when cold, be in the hardened condition and will be quite as liable to crack if rapidly or unevenly heated again as any hardened piece of tool steel. Being hard, it will require softening before any chipping, filing, or machining can be done. These troubles, however, may be avoided by allowing the forged, rolled, or stamped article to cool slowly over the range 800°—600° C. in order that the carbon change may take place and the steel thus becomes soft.

Stainless steels which contain more carbon than that indicated above, if quenched or air-cooled from high temperatures, are comparatively soft to the Brinell test owing to the production of austenite. Such steels, though soft, are unmachinable, the material becoming hard when stressed. Austenitic samples also harden when tempered at about 600° C.; for instance, an actual sample had a Brinell hardness number of 270 when water-quenched, and one of 444 after being tempered at 600° C. Such hardening after tempering has been noticed by several cutlery manufacturers who have, by accident or otherwise, hardened their knife blades from too high a temperature. Such a practice, however, is not to be recommended, as a coarse grain is thereby produced in the knife blade.

Stainless steel is tempered in the same way as ordinary steel, but higher temperatures are required. A corresponding series of temper colors are formed at the higher temperatures necessary to soften the steel. For example, the following colors were obtained, at the temperatures indicated, on a hardened sample of the steel:

| | |
|---|---|
| Straw | 300° C. |
| Brown | 400° C. |
| Reddish purple | 500° C. |
| Light blue | 600° C. |
| Bluish violet | 650° C. |
| Grayish violet | 700° C. |
| Gray | 750° C. |

Stainless steel has its maximum resistance to corrosion when in the hardened condition. It is then practically unaffected by exposure to moist air, fresh or salt water, or to such organic acids as occur in fruits. Samples buried in soil for three months have retained their original polish, and others have been immersed in vinegar or salt water for days without showing the slightest signs of attack. Tempering the hardened sample up to about 50° C. does not affect its resistance appreciably. Such tempering has also little effect on its hardness. Tempering at higher temperatures lowers the resistance

*From the *Journal of the Society of Chemical Industry*, Nov. 30, 1920, and *Chemical News*, Dec. 31, 1920.

[1]The word "stainless" has been retained because it is in general use; "unstainable" is, of course, the correct term.—Ed.

to corrosion, but even in the soft condition the metal is only slowly attacked. Such soft material, for example, is stained by vinegar, but a sample weighing 60 grms. only lost 0.04 g. after three weeks' immersion. A sample of nickel-chrome steel hardened and tempered so as to give the same tensile strength lost during the same time 25 times as much.

Nitric acid, strong or weak, does not dissolve stainless steel either in the hard or soft condition, nor is the steel attacked by concentrated or dilute solutions of ammonia, nor in a moist atmosphere containing ammonia fumes. Sulphuric and hydrochloric acids attack it readily; a 10 per cent solution of the latter in alcohol forms a convenient etching reagent for microscopic work. Dilute solutions of sulphuric acid, at ordinary temperatures, attack stainless steel considerably faster than ordinary mild steel.

The opinion has been held that the non-corrosible properties of stainless steel are only obtained when it is highly polished and that they are then confined to the surface. This is not correct. It is well known that metals in general have an increased tendency to corrode after they have been cold-worked. Stainless steel is no exception. Turnings of this steel are in a highly distorted condition and hence will rust. Similarly, the surface of a bar from which heavy cuts have been taken is distorted and is more likely to rust than one from which a fine finishing cut has been taken. A ground or polished surface will be still more immune. That polish, however, is not essential is shown by the resistance to corrosion exhibited by a fractured surface which has been obtained without distortion.

In addition to its resistance to corroding influences, stainless steel does not scale to any extent when heated at any temperature up to 800°—850° C. A sample heated for seven days in the range 700°—825° C. lost 0.7 per cent of its weight, whereas a piece of ordinary steel heated with it lost 17 per cent.

The suitability of any new type of steel for use in engineering work of any description is largely judged by its behavior under mechanical tests. A short description of the results of such tests on stainless steel will be of interest. After oil- or air-hardening from a temperature of 900° C., followed preferably by slight tempering at 200°—400° C., stainless steel has mechanical properties comparable with those of the well-known "100-ton" air-hardening nickel-chrome steel. When tempered in the range 650°—750° C., it gives tests highly suitable for many engineering purposes. The values obtained depend on the composition of the steel, but in general are in the following ranges:

| | |
|---|---|
| Yield point | 30—55 tons per sq. inch |
| Maximum stress | 45—65 tons per sq. inch |
| Elongation | 15—28 per cent |
| Reduction of area | 35—65 per cent |
| Izod impact | 25—70 foot-lb. |

Tempering in this range of temperature (650°—750° C.) is also interesting commercially in that the hardness, and therefore the tensile strength only, falls very slightly as the temperature increases. When a number of articles have to be tempered to produce a given tensile strength, quite a wide range tempering temperature is permissible—obviously a desirable thing commercially. On the other hand the hardness falls very rapidly in the range of 550°—650° C., and the difficulties of tempering in this range are correspondingly great.

During the war the great bulk of the stainless steel produced was used for airplane valves. Its value for this purpose lay, apart from its non-scaling property, in its superior strength at a red heat. The exhaust valves, especially of some of the large aero engines, frequently reach a temperature of 750° or 800° C., or even higher, and it is necessary that the valve should have sufficient strength at such a temperature to secure that the stem does not elongate during running. Actual tests obtained on testing mild steel and stainless steel at high temperatures gave the following figures:

| Tensile strength at | Mild steel | Stainless steel |
|---|---|---|
| 600° C. | 11.84 | 24.24 |
| 700° C. | 6.8 | 12.08 |
| 800° C. | 5.04 | 6.64 |
| 850° C. | 4.12 | 6.64 |

By increasing the carbon content of stainless steel, still higher values may be obtained, *e.g.*, 15—17 tons at 700° C. and 7.5—8.5 tons at 800° C.

The development of the uses of stainless steel was very largely held up during the war, since practically the whole of the steel made was used for war purposes. It may be confidently expected, however, that the near future will bring about a very noticeable development in the number and variety of its applications. It will also be found that stainless steel is not one steel but a group of steels. Just as in the far-off days "steel" was regarded as a hard product of iron, and little or no attempt was made to grade it into harder or softer varieties, so at present stainless steel is to most people a product having only one distinct set of properties, many regarding it solely as a special type of cutlery steel. In times gone by, as the use of steel became more general, it was realized that by varying the content of carbon or manganese, steels of widely different intrinsic hardness could be produced, and for each purpose some definite "temper" of steel was best suited. In the same way, as the use of stainless steel becomes more general, it will be found that products of different intrinsic hardness (corresponding to the varieties of ordinary steel) can be produced, all of them having the distinguishing property of great resistance to corrosion, but varying among themselves as soft or mild steel differs from file steel. For each use of stainless steel there will be an optimum "temper."

## HYDROELECTRIC PLANT OPERATING UNDER A 5,400-FT. HEAD

WHAT is probably the highest-head hydroelectric plant in the world is installed at Fully, Switzerland, operating at a net head of 1,650 m. (5,412 ft.). The installation is near Martigny, in the Rhone Valley, and operates from an Alpine lake 2,150 m. (7,000 ft.) above sea level. The Pelton wheels are fed by a pipe line about 4.6 km. (2.85 miles) in length. This is connected to a tunnel 500 m. (550 yd.) long, which is partly under pressure. The generating station contains four wheels, each of 3,000 horsepower, which run at 500 r.p.m.

Each bucket is exposed more than eight times a second to the blow of the jet leaving the pipe at a velocity of about 180 m. (590 ft.) per second. The wheels therefore had to be designed with extreme care. These wheels have an over-all diameter of 3.715 m. (12 ft.) and are of forged steel. They carry fifty-four buckets each and are so designed that no part either of the disk or the buckets is subjected to a higher tension than 1,000 kg. per square centimeter (14,200 lb. per square inch). Even in case of runaway this takes care of a speed 50 per cent above normal. The buckets are carried in a mortised groove and are fixed tangentially by formed keys driven axially between them. The whole makes a very rigid assembly with the disk.

Water from the feed pipe is conducted to each turbine by a cast-steel pipe 250 mm. (10 in.) in diameter, provided with a manually operated equilibrium valve. The jet pipe fixed to the bedplate under the turbine has a nozzle of tempered steel, the water discharge from which is regulated by a steel needle which moves in the axis of the jet pipe. The needle is always inclined to open when affected by the water pressure. It can be closed by a hand-operated screw, by oil-pressure mechanism or by the automatic governor. A cast-steel deflector placed between the nozzle and the bucket wheel is raised or lowered by the action of the governor, and when lowered causes a deviation of the jet away from the bucket wheel. The governing action is said to be particularly sensitive.—Abstracted from *Engineering* (London), Dec. 24, 1920, through the *Electrical World*, March 5, 1921.

# The Salt Wells of China

## Primitive Apparatus Used for Sinking Wells and Drawing Up the Brine

By Robert G. Skerrett

EVEN though China does trail in the march of civilization, still her people give to the fair-minded Occidental ample warrant for admiring wonderment.

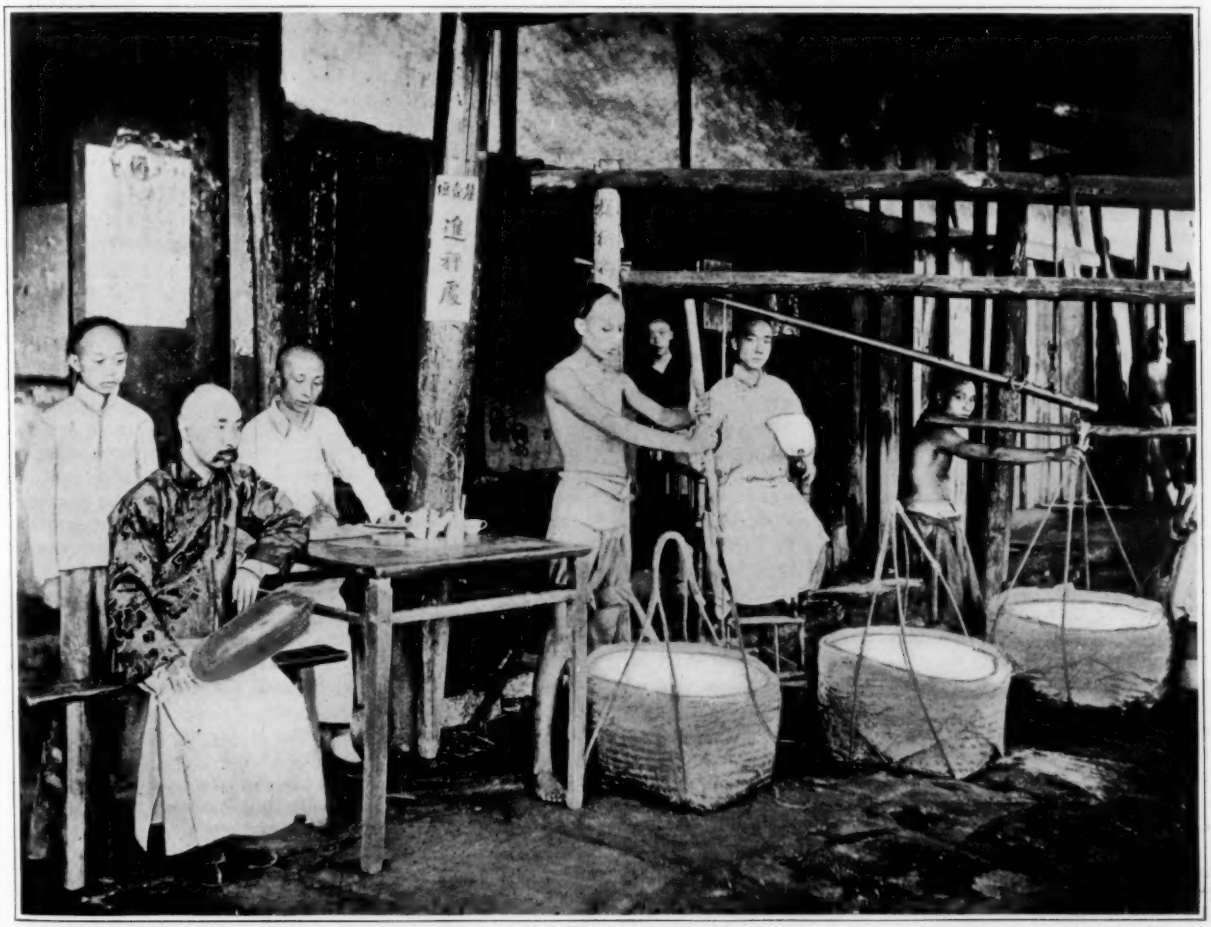
For centuries upon centuries those ingenious Orientals have applied with exceeding cleverness the fundamentals of physics and mechanics to the mastering of many difficult tasks. In some of their engineering achievements they have indubitably set the pace in much that is commonly deemed essentially modern among us. In none of her varied activities does China show this more strikingly than in the prosecution of certain departments of her very important salt industry.

Probably a thousand years or so before we bored in search of oil, gas, water, etc., the Chinese were drilling deep into the geological strata in their quest for greater supplies of indispensable salt. This was especially the case in the provinces remote from the sea where it was not possible for them to satisfy the demand by simply evaporating the ocean's abundant brine or similarly treating the outpourings of springs carrying a saline charge. To tap the subterranean store, the Chinese in the less favored districts have been obliged to bore to a depth of quite 4,000 feet; and to gain their goal they have had to penetrate through successive layers of interposed rock.

That they have succeeded in those undertakings is all the more remarkable when we contrast their primitive facilities with the instruments and apparatus which we now employ in kindred operations. True, we reach our objective quicker, but even so the driving of a well of comparable magnitude is an expensive job and we muster to its execution special tools skilfully fashioned and use drills made fit for their exacting work by the research of the metallurgist. Cables carefully manufactured for the purpose carry the load of the suspended metal implements, and the strands of these hawsers must be strong and elastic enough to bear the alternating stresses set up by the steel masses as they are lifted and dropped in pounding their way downward into the bowels of the earth.

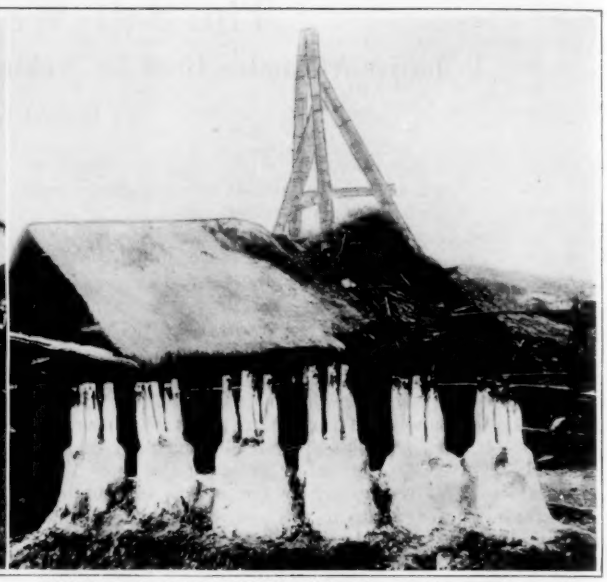
And then, in order to handle the heavy weights involved, we have devised power-driven machinery capable of operating hour in and hour out, day after day, with a minimum of human supervision. Ruggedness and dependability are the outstanding characteristics of the apparatus, and the attendants always have at their disposal enough mechanical energy to minimize the burden laid upon their muscles. According to the method adopted, gas, oil, or steam may furnish the primary power; and the electric motor is now figuring in this field of industry. And how does the Chinaman attain his end; and what are the aids which he depends upon?

But before describing his age-old appliances and practices it might be well to sketch in a general way the salt industry of



SALT BEING WEIGHED IN THE PRESENCE OF A GOVERNMENT OFFICIAL. THE SALT INDUSTRY IS HEAVILY TAXED

HAULING THE BRINE UP A TRESTLE FROM WHICH IT FLOWS THROUGH BAMBOO PIPES TO THE EVAPORATORS



CEMENT-COVERED BAMBOO JETS OF A GAS WELL. THE GAS IS USED IN EVAPORATING WATER FROM THE BRINE

China so that we may visualize its outstanding significance in the economic life of the nation. This will increase our astonishment at the Oriental reluctance to adopt up-to-date equipment in prosecuting the business. Normally, the domestic output of salt in the United States is in the neighborhood of 5,000,000 tons and represents a value of approximately $12,000,000 annually; while in China, ordinarily, the tax alone each twelvemonth on salt is several times this sum. Plainly the industry is of monumental proportions.

China's salt gabelle is an institution of antiquity, and for many centuries the salt trade of that country has been a government monopoly. Indeed, the income derived in this way has more than once figured as a prime factor in guaranteeing loans made by foreign nations. This is not hard to understand if we bear in mind how the revenue was garnered. Before the establishment of the Chinese Republic the management of the salt tax was a subject on which little information was available. At that time China was divided, for purposes of administration, into eleven salt areas, seven of which produced sea salt, two lake salt, and two well salt; and these zones were subdivided into numerous districts—the object being to equalize in a measure the natural advantages or conditions prevalent in the several regions.

Then the government, besides levying a tax upon the salt, acted the while as middleman between the producer and the retailer, and not infrequently played the part of transportation agent and wholesaler; and the authorities did not hesitate to put upon the traffic all that it would bear. Salt has paid as many as forty-three different taxes during the various transactions between the producer and the ultimate consumer. These abuses have been modified since 1913, when the Chinese Republic secured an international loan of $125,000,000 and offered the salt revenue as a security. Following that arrangement, the whole administration of the salt levy was reorganized, and the appreciation of silver has added greatly to the value of the income since 1914. The total revenues from the salt gabelle in 1916—the latest data available—amounted to $72,440,559, Mexican. China jealously guards the whole salt trade, and strictly prohibits the importation of any of this material.

The two most interesting phases of the production of salt in China are those exemplified in the procedures followed, respectively, in the provinces of Hankow and Szechwan, where the brine is raised to the surface from considerable depths. In the Hankow district the annual output is about 15,000 tons and this is obtained from a region where gypsum has been worked for quite two centuries. Salt, *i.e.*, sodium chloride, is a fairly common accompaniment of gypsum deposits; and the salt-yielding layers in Hankow lie at depths ranging from 400 to 900 feet. The mineral is reached by sinking vertical shafts. The usual practice is to mine for gypsum for two or three years and then to close the pit for a period of twelve months, during which time brine is the outcome of natural leakage or is formed artificially by pouring water into the galleries, whence it flows down the slopes of the excavations which follow the dip of the gypsum.

Geologically, the salt is either held in the pores of the soft rock or it lies interspersed as sheets between the gypsum, and in breaking out the rock the salt is exposed so that the inundating water can penetrate and dissolve it. At the end of a twelvemonth sufficient brine accumulates to furnish work for from one to five months, after which the gypsum is again mined for an interval of two or more years. In this way the removal of gypsum and the leaching out of the salt go on alternately.

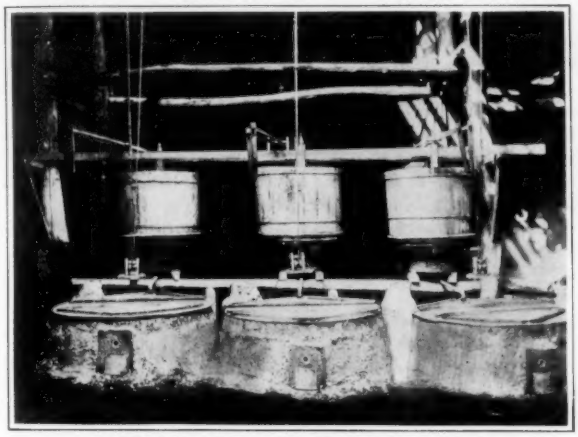
The brine is raised to the surface by a simple windless and a rope to which wooden buckets are attached, and at the pit mouth the salty fluid is poured into nearby large wooden tanks sunk into the ground. From these reservoirs it is baled out into troughs, covered by mats, and these conduits convey it a distance of a few hundred yards to the furnaces, where the brine is boiled in iron pans to stimulate the evaporation of the water. These pans are disposed in batteries of from three to five to a furnace, and are set up beneath tiled sheds with open sides. The pans are made of boiler plate and are three feet in diameter and eighteen inches deep. The furnaces are built in pits lined with brick and are arranged so that the boiling pans are just above the ground level. The fuel is coal procured in the neighborhood of Hankow.

Coolies ladle the fresh brine into the caldrons, and as the fluid boils incessantly the water is rapidly vaporized. The salt precipitates as the density of the liquid increases, and at the proper stage the deposit is dipped out and dumped into split bamboo baskets. The salt thus produced is distributed to the consuming areas by small dealers who carry it about in two baskets slung at the end of a pole—the total load being around 100 pounds. The salt so manufactured is snow white, very fine, crystalline and of good flavor, though slightly bitter. This is probably due to the presence of an excess of magnesium. Apart from using salt for seasoning his food,

feeding livestock, etc., the Chinese employ it to preserve both meats and vegetables, and the nation at large requires immense quantities for this purpose.

Beyond question it is in the province of Szechwan that Chinese ingenuity shows at its best in the production of salt. There, fully 1,100 miles up the Yang-tze-Kiang from the sea, the Chinese have gone down anywhere from 2,000 to 4,000 feet in quest of brine; and in the course of a year they manufacture on an average substantially 385,000 tons of the commodity. Szechwan is able not only to supply the salt needs of its own millions of inhabitants but it sends annually into near-by provinces a matter of 82,000 tons of the stuff.

The leading producing centers of salt in the province of Szechwan are Tzuliuching and Wutungchiao. The wells



INTERIOR OF AN EVAPORATING HOUSE

around Tzuliuching are by far the most important, and are able to furnish about half of all of the salt obtained in the province. The boring of a well does not differ in principle from that commonly practiced in the search for oil and gas in this country, but the agencies relied upon are notably dissimilar. It is not hard to understand this when we grasp the somewhat isolated position of the province of Szechwan. It lies beyond the gorges and rapids of the Upper Yang-tze, and that waterway has for ages been the main route of commercial intercourse. Inasmuch as freight rates by that dangerous and tedious channel of trade are very high, and goods often have to be packed for some distance by man and beast, there was little inducement in the decades gone to introduce machinery which was sure to be too costly. Therefore, the Chinese owners of a salt concession wisely elected to depend as much as possible upon the brawn of the willing coolie who could be hired for a pittance.

To make sure that the bore of his well is vertical, the Chinaman has adopted a very effective means of steering his drill straight down at the start and of forcibly directing its course for a while thereafter. To this end it is customary for him to excavate a shaft to a depth of 200 feet, and in the center of this he sets upright and steadies by rock ballast a number of nicely hollowed-out tree trunks joined together to constitute a single wooden pipe. The upper portal of this guideway is protected by a limestone cap pierced with a 10-inch hole. With this installation complete the actual drilling of the well is begun.

Instead of the towering derricks characteristic of our oil fields, the Chinaman substitutes a low framework which supports a lever pivoted so that it may move in the vertical plane. At the short end of this pole is hung the drill rope with its pendant tools. Parallel with the longer arm of the lever are two benches—one on either side, and upon these the men stand who operate the "jumping beam." By stepping on the lever it is depressed and the drill raised a foot in the shaft. Next, when the coolies hop off, the drill drops as the long arm of the lever rises. The number of men needful for this work is regulated by the load represented by the tools and the weight of the connecting line. The beam gang is divided into two squads, one on either bench, facing each other. The several men place their right feet on the lever, and at the word "go" all of them step with their left feet across and on to the neighboring bench, withdrawing the while their weight from the beam. Promptly all hands swing around and repeat this operation, and in the course of a minute the lever can thus be raised and dropped from ten to twenty times—the drill hammering away under ground in unison. This interesting method of well drilling is illustrated in the frontispiece of this number.

The drill is generally a 12-foot bar of iron having a cutting face with a spread of 4 inches, and the tool weighs about 200 pounds. Above this drill is suspended another bar encased in bamboo, and its function is to add to the blow of the descending drill something after the fashion of the "drilling jars" used in our oil and gas fields. It supplements the hammer blow of the drill and, also, helps to jerk the drill free from the rock on the upward pull of the cable. The latter is not fashioned of hemp, as one might suppose, but is made up of strands of split bamboo—commonly three of them, and this line is secured by a length of Manila rope to a hook engaging an iron eye on the short arm of the beam. The lower end of this hook has a heart-shaped grip, and every time the drill is raised the operative at the well mouth gives it a half twist, and in this manner causes each succeeding

SOME OF THE PRIMITIVE TOOLS USED FOR RECOVERING LOST DRILLS, SINKER BARS, ETC.

blow of the drill to strike at a different angle. This insures the boring of a round hole and tends to make the jamming of the drill less likely.

After ten minutes of hopping on and off the "jumping beam," the coolies rest while the drill rope is being lengthened. Apparently the eight-hour-day is the rule in that section of China, because three shifts are employed to keep the work going night and day. The hole is deepened at an average rate of 3 feet every twenty-four hours. The cost of drilling a well varies according to the depth, and is said to run from $2,000 to $17,000. If nothing unforeseen happens to interfere with the execution of the task, it is possible to drive a

well in from three to five years, but this may be much prolonged by tools breaking off in the hole, by the inundation of the well by subterranean streams, and by the halting of operations through all too frequent litigation. Indeed, with these contingencies arising, the successful completion of a well may involve a period of anywhere from ten to twenty years. In a country where time counts for little this does not dismay, and it is a fact that native capitalists look with marked favor upon salt well enterprises though it may be a decade or so before anything is realized on the investment.

Should water enter from an underground source during drilling, the Orientals resort to a well-tried remedy. A plug or wad of coarse grass is forced down the bore to a point below the leak, and on top of this obstruction is poured a composition of lime, clay, and wood oil. This mixture hardens rapidly, effectually closes the water-bearing seam, and is subsequently pierced by the drill in its deeper quest for the salty store.

Chinese engineers have shown much cunning in devising tools for the recovery of drills, etc., which have been lost by the breaking of the bamboo line, and these are so patterned that they will meet successfully well-nigh every accidental condition. They range from heavily weighted spears to single and triple rods carrying one or more barbs calculated to catch some part of the lost gear and make it practicable to retrieve it.

With the well bored and the deeply-lying brine reached, then comes the problem of raising the salt-laden fluid to the ground's surface, 1,000, 2,000, 3,000, or 4,000 feet above. The bailers are formed of sections of bamboo having a diameter of four inches, and a number of these are joined together to constitute a container from 50 to 100 feet long. They are reinforced frequently with windings of wire and twine, and have capacities of from 300 to 600 pounds of brine. The bailers are drawn up by means of buffalo winches upon which are wound the bamboo-ribbon ropes to which the bailers are attached. A lift from a deep well requires ten or twenty minutes; and so hard are the buffaloes worked that they are allowed to rest for several hours after they have raised the bucket twice.

When the brine has been brought up to the surface, the fluid, if the dip of the land permits, flows by gravity to the evaporator houses, being distributed through bamboo pipe lines which are made water-tight at the joints with windings of shredded bamboo and Chinese cement. Should the well mouth be below the evaporator sheds, the brine is elevated by one or more "dragon-bone lifts," *i.e.*, wooden chain pumps, or carried by coolies to a tank upon a raised trestle whence it may feed downward through bamboo conduits for possibly a thousand feet or more. The evaporator pans in the Szechwan district are heated by natural gas, which is frequently encountered when driving salt wells. The Chinese do not cap their wells in the usual acceptation of the term, but they build a gas-collecting chamber around the top of the well, and from there lead the gas through bamboo pipes to the burners beneath the iron pans. The burners are formed of bamboo and are enveloped in cement made of lime, granulated tiling, and sand or mud. On the roof of the gas-collecting chamber are mounted similar burners, and these are lighted to stimulate combustion when the gas pressure rises beyond that needed to supply the evaporator jets. The Chinese do not use valves to regulate the emission of the gas, but allow it to burn steadily at all the burners when there is enough of it, and simply cover up some of these when the supply begins to wane.

It is a matter of record in the salt industry of the United States that the machinery and metal equipment deteriorate rapidly. Therefore, the Chinaman with his simple apparatus, for the most part of wood and vegetable fiber, has adopted mediums calculated to last fairly well and to be easy of replacement. However, more modern facilities are winning recognition in the Tzuliuching district, and steam hoists have gained a foothold. The first of these was introduced about 1915, when an epidemic among the buffaloes and oxen threatened to halt activities. The steam plants are built in Hankow and Shanghai, and steel rope is sent to the salt wells from the United States. The salt is produced at a cost of about half a cent a pound, and the laborers are paid around $2.50 a month, their food being furnished gratis.

## PHYSICAL PROPERTIES OF ICE

PROFESSOR MOTONORI MATSUYAMA of the Kyoto Imperial University, Japan, publishes in the October-November number of *The Journal of Geology* the results of his investigations carried on at the University of Chicago on "Some Physical Properties of Ice."

In introducing his article the author says: "The motion of an ice sheet along the mountain slopes and over a large area of the continent may be caused by more or less different forces. Besides the external forces it is also important to know what is the behavior of the ice itself in such motion. Numerous works have been published on these problems, among which those of McConnell and Mügge are famous and have been referred to by many authors. According to them an ice crystal can be sheared more easily in the direction parallel to the basal plane than in any other direction."

The author's own experimental investigations covered such problems as that of the determination of the *Limit of Elasticity, the Modulus of Rigidity, the Ratio of the Stress to the Strain, Torsion by Constant Force, Torsion by Increasing Force, Bending* and *Crystalline Structure.*

The author finds:

(1) In some specimens of ice a sharply defined elastic limit was noted, though in other cases it was not so clearly shown.

(2) The modulus of rigidity of ice, when the crystals are perpendicular to the axis of the test piece, is very small compared to that of metals, and is about $2 \times 10^6$ c.g.s. There is a slight indication that it is greater when the shearing is parallel to the base of the constituent crystals than when it is perpendicular.

(3) The Young's modulus is also very small compared to that of metals. It is largest when the crystals are parallel to the length of the test piece, and has the numerical value about $20 \times 10^{-6}$ c.g.s.

(4) Elastic fatigue was marked after repeated torsion. On account of the fact that it was often necessary to use certain bars in successive experiments during which they suffered from different amounts of fatigue, it was difficult to compare the results bearing on ice bars with crystals parallel and perpendicular to the length of the test piece. Still there were some indications that beyond the limit of elasticity the former orientation was stronger than the latter against torsion. In the case of bending experiments, this was clearly shown.

(5) The torsional deformations both by constant and by increasing forces were observed and the result is shown by curves, though no mathematical conclusions were made. The recovery curves showed that the observation was approaching the stage where no recovery would take place after removal of the force.

(6) When an ice bar with crystals parallel to its length was bent, the bent portion showed the change of optical character, the extinction swinging around the curve. In each crystal when the bent specimen consisted of parallel crystals running horizontally across it, parallel straight lines were observed.

The conclusion is reached that these facts seem to show that gliding planes parallel to the base of each crystal are not the controlling factor in the deformation of ice and probably are not even an important factor. But instead, adjustments along the contact surfaces of adjacent crystals and perhaps the development of planes of weakness in the constituent crystals parallel to their long axis seem more effective in the process of deformation.

# Toning Photographic Prints*

## Methods Used to Bring Out the Shades and Shadows in Various Colors

THE toning operation has for its purpose the development of the shades and shadows in the ordinary photographic print by subjecting it to the action of various chemicals which produce different color effects in the picture. For this purpose, photographic papers are divided into two classes. The first class, called "direct printing papers" consist of those papers such as "silver citrate paper," "albuminous paper," "ordinary blueprint paper," "celloidine paper," "cello," etc., which print directly on exposure to light so that it is possible to watch the formation of the picture and stop it at any desired point. The second class of photographic paper must be developed after exposure before the picture appears. Such papers are "gelatin bromide, gelatin chloride, gelatin chlorobromide paper."

### DIRECT PRINTING PAPERS

The active constituent of these papers consists of an emulsion of silver chloride in gelatin, albumen or colloidon in the presence of citric acid and an excess of a soluble silver salt (citrate or nitrate). The latter absorbs the chlorine, disengaged in the decomposition of the silver chloride by exposure to light. The soluble silver salts are removed by washing and the undecomposed chloride of silver by means of a "hypo" bath. At the same time the subchloride of silver ($Ag_2Cl$), which forms the image, is converted into the chloride of silver and the metal itself:

$$Ag_2Cl = AgCl + Ag.$$

The picture produced is brownish purple in color at first, changing into a reddish yellow tone after fixation. The toning operation improves the color of the picture, and, what is more, lends permanency to it.

### TONING OF DIRECT PRINTING PAPERS

This is accomplished entirely by the aid of gold and platinum salts, and also the salts of the platinum group of metals. The colors that are obtained lie between black and brown, in reddish, bluish or purplish shades. Toning can be effected before or after fixing.

### GOLD TONING

Either auric chloride ($AuCl_3$) or protochloride of gold (AuCl) can be used for this purpose, preferably the latter, for then the clearness of the picture is not impaired by the substitution of too much of the gold for the original silver. The reactions, taking place, are as follows:

$$AuCl_3 + Ag = 3AgCl + Au.$$
$$AuCl + Ag = AgCl + Au.$$

The color of the picture varies from an orange red to a violet black, according to the quantity of gold that replaces the silver. The degree of the alkalinity or the acidity of the toning bath affects the tints in the picture as well. One point that must be observed carefully is that the excess of the soluble silver salt (silver nitrate or silver citrate) must be washed out before the toning operation, as otherwise the gold chloride is decomposed and a part of the gold is rendered useless for toning.

### PREPARATION OF THE TONING BATHS

The bath is made by adding a weak alkaline reagent such as bicarbonate of soda, acetate of soda, borax, magnesia, carbonate of lime, etc., to a solution of auric chloride until the yellow color of the same has disappeared, indicating the transformation of the salt into the protochloride of gold (AuCl) which is colorless. It is very important that the toning bath be either neutral or what is better slightly acid. If the bath is alkaline the excess of the alkali decomposes the active principal AuCl to form suboxide of gold ($Au_2O$). This black powder then discolors in the alkali to form a subaurite of gold, which is colorless but without any action in toning. The more alkaline the bath, the more rapidly it loses its potency. For this reason the use of sodium acetate is preferred in that it leaves the bath slightly acid. The insoluble basic compounds such as $CaCo_3$, give neutral toning baths, which keep their effectiveness much longer than the alkaline baths and are just as potent.

### TONING AND FIXING COMBINED

It is possible to accomplish both the operations of toning and fixing in one bath. The bath must contain (1) chloride of gold and (2) sodium thiosulphate (hypo). The function of the latter is not only to dissolve the AgCl but to form a hyposulphite of gold and sodium with $AuCl_3$, which then forms the active principle of the toning bath.

Various other substances may be added to the bath as follows:

(a) Alum, to tan the gelatin. [Formalin is preferable to alum for this purpose, as alum reacts with $Na_2S_2O_3$ (hypo)]

(b) Acetate of soda, to avoid the precipitation of sulphur as a result of the above reaction.

(c) Lead salts (acetate or nitrate) to increase the potency of the toning bath.

The action of the lead salts is very much like that of a catalyst, as a very small quantity will promote the deposition of a large amount of gold. It is known that the reactions that take place are very complex and that a large variety of compounds are formed. It appears that the lead first replaces a part of the silver in the picture, which is then replaced more readily by gold.

The lack of permanency in photographs subjected to the combined action of a toning-fixing bath has been known for some time. This has been found to be due to the hypo left behind on the print. Careful washing will eliminate all traces of the salt and give pictures which are lasting.

### TONING IN PLATINUM

Photographs may be toned in platinum directly from the silver image or else from the gold toned image. Blacker shades are obtained than with gold. The platinum salt used for this purpose is potassium chlorplatinate and the reaction that ensues is as follows:

$$PtCl_2\ 2\ KCL + 2\ Ag = 2\ AgCl + 2\ KCl + Pt.$$

It is essential that the bath be acid. It is preferable to acidify by means of the mineral acids, such as sulphuric and phosphoric, as the organic acids are reduced with precipitation of platinum. The combined toning-fixing bath cannot be used for the reason that the acid in the solution would decompose the hypo. Salts of other metals in the platinum group, such as palladium, iridium and osmium, act in a similar manner. The chlorpallodiate of potassium has been used as a substitute for platinum for economical reasons. Nitric acid, being a strong oxidizing agent, cannot be used in platinum toning.

Gold-toning baths become inactive when the Au content is reduced to 30 per cent. Platinum baths can be exhausted to a far greater degree before becoming impotent, the platinum content being 11 per cent at that point. Silver pictures toned

*Translated for the *Scientific American Monthly* from *Chimie et Industrie*, 1920, 3, 10.

with platinum still contain about 25 to 30 per cent of the original silver. In gold toning the silver content is very much higher.

### MODIFYING THE COLOR BY PHYSICAL DEVELOPMENT

A wide range of color tones can be obtained by subjecting photographs on print paper which has been exposed only slightly to light to the action of physical developers. Much finer results are obtained than in the toning process. The distinction between physical and chemical developers lies in the fact that the toning effected by the former does not involve any chemical change in the image, such as the substitution of one metal for another. (Au and Pt for Ag.)

The process is somewhat as follows: The picture is printed from the negative until just the faint outlines of the image are perceptible. Then it is treated with a developer, consisting, for example, of 100 parts of water, 1 part of metol (metol is a trade name for a photographic developer. Its chemical name is methyl pora-amino—phenol sulphate), and 10 parts of a concentrated solution of gum (gum-water). The color of the picture varies according to the time of exposure in printing and to the time of development.

The one important disadvantage of this process is that the colors that are produced by it are very variable in nature. The tones run the gamut from bluish black to black. The developer intensifies the color of the photograph, acting on the silver salt contained in the print paper. After development the picture is washed and fixed in a bath of hypo. The gum acts as a colloid in retarding the reduction of the soluble silver salt and in mitigating the action of the physical developer.

### PHOTOGRAPHIC PAPERS REQUIRING DEVELOPERS

The active principal in these papers consists of an emulsion of silver bromide or silver chlorobromide in gelatin. The paper is exposed to the action of light for a short time and the image is brought out by means of chemical developers in a manner similar to the development of negatives.

### VARIATION OF THE COLOR OF THE PHOTOGRAPH BY DEVELOPMENT

The color of the picture can be varied by modifying the composition of the developer. The gelatin-silver chlorobromide papers are very much more susceptible to such toning than the gelatin-silver bromide papers. The shades run from a warm brown to a black in the latter case, while in the former greenish black tones, brown green, sepia, blood red colors are obtained by varying the time of exposure, the dilution of the developer and the duration of the development. The difference in color is due only to variation in the size of the grains of the silver, reduced by the developer.

### PROCESSES OF TONING DEVELOPED PICTURES

These processes are classed as follows:

(a) Toning by means of various metallic salts;
(b) By sulphuration of the silver;
(c) By fixation of coloring matters on the silver after its transformation into compounds, acting as mordants;
(d) By the action of quinone and an alkaline bromide.

### TONING BY MEANS OF VARIOUS METALLIC SALTS

This is done by the aid of a solution containing potassium ferricyanide ($K_3Fe(CN)_6$) and a metallic salt whose ferrocyanide is insoluble. The silver in the photograph acts as a reducing agent, transforming the ferricyanide into ferrocyanide ($K_4Fe(CN)_6$) and silver ferrocyanide ($A9_4Fe(CN)_6$). The metallic salt in combination with the ferrocyanide of potassium gives a colored compound which produces the tone of the photograph.

The following conditions must be observed in order that the process prove successful:

1. The metallic salt must give a colored insoluble ferrocyanide.
2. The metallic salt must give a compound with $K_4Fe(CN)_6$, which is soluble in water or in a compound which is itself soluble in water and must be without any action on the silver of the photograph.

As silver ferrocyanide is formed by the reaction of $K_4Fe(Cn)_6$ and the soluble silver salt before the toning reaction, it is necessary that the solution contain a substance, capable of dissolving the $Ag_4Fe(CN)_6$ without attacking the colored ferrocyanide so as to prevent the deposition of the orange colored $Ag_4Fe(CN)_6$ on the white spaces in the photograph. The metallic salts used for this purpose are uranium, copper, iron, molybdenum, cobalt and vanadium compounds.

### TONING IN BROWN AND BLOOD RED BY MEANS OF FERROCYANIDE OF URANIUM

Two uranium ferrocyanides are known:

A. $K_6Fe(CN)_6(UO_2)_3 + 12H_2O$.
B. $K_2Fe(CN)_6(UO_2)_3 + 6H_2O$.

A is a fire red compound quite soluble in water, formed by the addition of a diluted uranyl salt to a concentrated solution of $K_4Fe(CN)_6$ in excess. B is a brownish red insoluble salt, formed by adding the $K_4Fe(CN)_6$ to the uranium salt solution.

In this toning process two precautions must be taken. First, the solutions should be acidified with acetic acid and second too great an excess of $K_4Fe(CN)_6$ should be avoided. If the Ur salt is in excess, then a brownish red picture is obtained; when the $K_4Fe(CN)_6$ is in excess, the first ferrocyanide of Ur (A), which is soluble, tends to form.

The nitrate of uranium is used generally. The photograph is just dipped into the bath and as the Ur ferrocyanide is somewhat soluble in water, the picture is washed for a short time only.

### TONING IN BLUE WITH FERRIC FERROCYANIDE

When a silver picture is treated with a concentrated solution of $K_4Fe(CN)_6$, containing ferric citrate or oxalate, the silver is replaced more or less completely by ferric ferrocyanide or Prussian blue ($Fe_4[Fe(CN)_6]_3$) resulting in the formation of a blue image. The choice of the ferric salt is important. Ferric chloride ($FeCl_3$) cannot be used as it forms silver chloride. The ferric ammonia citrate is used most of all.

The ferric salt should be freed completely of all ferrous compounds, as otherwise the bath becomes blue owing to the formation of ferrous ferricyanide ($Fe_3[Fe(CN)_6]_2$), which discolors the white spaces in the photograph. The washing with water should not be prolonged for any length of time, as the alkaline action of the water tends to decolorize the toned picture.

### TONING IN PURPLE BY THE AID OF CUPRIC FERROCYANIDE

For this purpose the purplish red precipitate of cupric ferrocyanide ($Cu_4[Fe(CN)_6]_2$), formed by mixing solutions of $K_4Fe(CN)_6$ and a cupric salt is used. The toning bath contains the latter, $K_4Fe(CN)_6$ and a solvent of the cupric ferricyanide, which forms directly in the bath. Potassium citrate ($K_3C_6H_5O_7$) is added to prevent the formation of the ferricyanide, but at the same time it does not impair the formation of the ferrocyanide which is the toning principal. The following equation shows what happens:

$$2Cu_3[Fe(CN)_6]_2 + 4Ag = Ag_4Fe(CN)_6 + 3Cu_2Fe(CN)_6$$

Ferricyanide — Ferrocyanide of silver — Cupric Ferrocyanide

### TONING IN REDDISH BROWN WITH MOLYBDENUM FERROCYANIDE

Ammonium molybdate, dissolved in acetic or oxalic acid, gives a reddish brown precipitate of molybdenum ferrocyanide with $K_4Fe(CN)_6$. The ferrocyanide dissolves in excess of $K_4Fe(CN)_6$ to form the double ferrocyanide of Mo and K. The Mo salt is used in a dilute solution. About 3 to 4% of $K_4Fe(CN)_6$ is added.

TONING IN VARIOUS COLOR BY USING MIXTURES OF FERROCYANIDES

The reddish uranium toned photograph can be shaded blue, more or less, by treatment with a ferric salt, which forms ferric ferrocyanide, replacing uranium ferrocyanide. The degree to which these substitutes can take place depends solely on the chemical properties of the various metallic ferrocyanides. The one that can be decomposed by a reagent can be replaced generally by the one that is not susceptible to decomposition.

Ammonia decomposes $Fe_4[Fe(CN)_6]_3$ but not $Cu_2Fe(CN)_6$. Hence, a picture toned in iron, when treated with an ammoniacal solution of a copper salt, can be made to assume any desirable intermediate shade between blue and reddish purple by stopping the replacement process at the proper point. It is also possible to tone photographs with certain metallic ferrocyanides which cannot act on the picture directly, but which can be substituted for the original silver of the image by the interposition of another ferrocyanide.

TONING WITH FERROCYANIDES IN TWO SEPARATE BATHS

The photograph may be dipped first in a solution of $K_3Fe(CN)_6$, whereat Ag + Fe $(CN)_6$ is formed and the excess $K_3Fe(CN)_6$ and K + $Fe(CN)_6$ is removed by washing. Then, any desired ferrocyanide can be formed on the image by a second immersion in a solution of the chloride of the metal. The AgCl that is precipitated and which dulls the picture can be removed by washing with a 5% hypo solution. This process admits of very general application.

TONING IN GREEN (FERROCYANIDE OF VA AND FE, AND FERROCYANIDE OF PB AND CO)

A dark green color tone can be obtained by immersing the photographs in a bath containing $K_3Fe(CN)_6$, vanadium chloride, perchloride of iron, oxalic acid and potassium oxalate. A bright green tone results when two baths are used. The first contains $K_3Fe(CN)_6$ and lead nitrate. This bleaches the picture forming lead ferrocyanide. Then, after the soluble lead salts are removed by washing, the picture is dipped in a solution of cobalt chloride, acidified with HCl.

TONING BY SULPHURATION OF THE SILVER

The process consists in transforming the silver of the photograph into stable sulphides of a brownish black to a sepia color. There are two methods which can be used. The first is to convert the silver directly into the sulphide and the second is to change it first into the chloride, bromide, or iodide and then into the sulphide.

TONING BY DIRECT SULPHURATION

Direct sulphuration is accomplished by the use of nascent sulphur or of the alkaline polysulphides.

Nascent sulphur may be prepared hot or cold. In the first case the photograph is treated first with formalin to prevent the gelatin from being injured by heat. The toning bath contains 50 grams of alum and 100 grams of hypo. When heated to 80° C. a reaction takes place which results in a deposition of nascent sulphur on the silver of the image. A sulphide is formed, toning the photograph. The white spots are not discolored. In using alkaline polysulphides, such as sodium bisulphide or liver of sulphur (a mixture of potassium salts and higher sulphides), it is found that discoloration does take place due to the sulphur being deposited on the white spaces in the photograph.

The process can take place in the cold by using colloidal sulphur. This is made by dissolving a mixture of $Na_2S_2O_3$ and a colloid (albumen, dextrin, gum arabic) in water and adding an acid, which decomposes the hypo, liberating the sulphur. The mixture becomes milky after a while and when this happens the picture is immersed therein. At first no change is noticed but after it has remained in the solution for 20 to 25 minutes and is then subjected to a prolonged washing, its color changes gradually to a brown and after an hour and a half of this treatment, the tone is developed fully. The whites of the photograph are not discolored. What probably happens is that the sulphur is retained by the gelatin in the photographic paper and does not react with the silver image until the metal has been converted into $Ag_2O$ by the oxidizing action of the wash water, while at the same time the sulphur is changed into $H_2S$. Then reaction takes place with formation of silver sulphide ($Ag_2S$). It is also likely that oxysulphides are formed and the tints that are obtained correspond to the existing proportions of the two sulphur compounds.

TONING BY INDIRECT SULPHURATION

In this process the silver is first changed into the iodide or bromide by the action of a mixture containing $K_3Fe(CN)_6$ and KBr or KI. Insoluble silver ferrocyanide is formed first and $K_4Fe(CN)_6$; the alkaline halide transforms the $Ag_4Fe(CN)_6$ into AgBr or AgI. The soluble $K_4Fe(CN)_6$ is removed by washing, and then the photograph is immersed in a solution of an alkaline sulphide. Reaction is instantaneous, a brown colored image resulting. When a halide of a metal is used, which itself will give a colored sulphide, the tone is different from that given when that substance is absent.

Cupric chloride can be used above. Then AgCl and $Cu_2Cl_2$ are formed. The latter remains with the AgCl and reacts to give copper sulphide (CuS) in the further treatment. It is not possible to wash out all the $CuCl_2$ from the picture with the result that the white spots remain discolored slightly.

SULPHURATION WITH COMPLEX SULPHIDES

Instead of the alkaline sulphides, the sulphomolybdate of ammonia or the sulphoantimoniate of soda can be used. In this case warmer tones are obtained, due very likely to the fact that a certain quantity of the metal (Mo and Sb), which is combined with the sulphur, participates in the reaction.

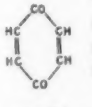
TONING IN VARIOUS COLORS BY MEANS OF BASIC DYES

The silver of the image is not itself capable of combining with dyestuffs directly, but it is possible to fix a certain number of basic dyes on it, provided it is first converted either into the iodide or else into an indefinite chromium compound, formed by the action of $K_3Fe(CN)_6$ and chromic acid on the silver image. The picture is mordanted in this way and can be dyed permanently with basic colors. These tint the gelatin as well, but the color is removed easily by prolonged washing with water. The paper itself, however, always retains some of the dye.

Various shades of red can be obtained with Pyronine B. Fuchsine, etc., blues with Malachite Green, Methylene Green 6B, yellows with Phosphine, Orange Acridine R, etc., etc.

The colors combined with the silver image by the mordanting action of AgI possess different properties from those in the original state. Sodium bisulphite ($NaHSO_3$) discolorizes malachite green, but not when it is fixed on the photograph. For this reason it is possible to decolorize the background without injuring the tone of the picture.

TONING IN COLORS BY MEANS OF QUINONE AND AN ALKALINE BROMIDE




An aqueous solution of quinone plus sour alkaline bromide will modify the color of silver images. A whole series of colors varying from a brownish black to sepia can be obtained according to the duration of the toning treatment.

What happens is not understood very clearly. It is possible that the color is due to the formation of perbromide of silver, according to the following equation:

$$C_6H_4O_2 + 2KBr + Ag = C_6H_4(OK)_2 + AgBr_2$$

Quinone — Potassium salt of hydroquinone — Silver perbromide

The analysis of the toned image has not confirmed the accuracy of this equation.

# Evolution of the Golf Ball

## From the Primitive Feather Ball to the Rubber-Wound Ball of Today

By Thomas C. Turner

THE Royal and Ancient Game of Scotland is a title often given to the game of golf, and it is well justified, at least, as regards antiquity, for few pastimes can antedate golf, and few if any can surpass it in popularity. With the exception of football, baseball and cricket no outdoor sport has so large a following, and yet as a popular game it is comparatively new, for in its early days it was, as its title implies, quite exclusive.

The first mention of golf comes to us in the form of an ordinance of the Scotch Parliament of 1457, when the game was very evidently played with such popular zeal as to give the impression that it might interfere with the then necessary training in archery, and at such periods as were set for this training the decree forbade the playing of *futeball* and *golfe*. For four hundred years following this the game remained almost entirely in its native land. Even by 1875 the Royal and Ancient game had made very little progress south of Scotland, with the exception of Blackheath Club, the Westward Ho of North Devon, the Royal Liverpool Club of Hoylake, and the Wimbledon Club, few clubs existed. In that year small courses were laid out both for the Oxford and Cambridge University Golf Clubs. At last the game took a sudden and popular hold, and by 1890 golf was the fashion.

It is not much over thirty years since its first appearance was made in America, for it was in 1894 that the first amateur championship was played over the old St. Andrews Golf Club course at Yonkers. The year following this the first amateur championship played under the auspices of the newly organized United States Golf Association, took place over the course of the Newport Golf Club, at Newport, R. I.

The very early golf of Scotland was naturally crude compared with the game as we know it, both in its courses, its clubs, and its balls. In those days but few clubs were used, and those almost entirely of wood. Today the average set comprises at least five irons in addition to the driver and brassie. With all the other innovations the ball, naturally was not to be overlooked, although that highly important item in the game did remain unchanged for four hundred years, until at last an inventive genius evolved something new. Golf in its first four hundred years had been played with a feather ball, with a leather cover; the ball was but little larger than the present type of sphere. The cover was a work of art so far as skill in its hand sewing was concerned. It was not possible in those days to have the highly finished surface of the cricket or baseball as we now use them, nor would it have been quite so beneficial to the game of golf, the seams as then produced being a distinct advantage to the flight of the ball. So many feathers were packed into one of these small balls that it has been said they would more than fill an ordinary hat before they were compressed. It may be readily imagined that such balls might cut or become ill-shaped under the heavy stroke of an iron, hence our forefathers used good common sense in standing to their wooden clubs. Such balls cost, even in those days, when labor was cheap, four shillings each, and of necessity made golf a somewhat expensive game.

EVOLUTION OF THE GOLF BALL

In the upper row the first two from the left are feather balls, and the second pair early smooth surface gutta percha balls. In the lower row the first two are hand hammered gutta percha balls, the third a filed surface ball, and the last a molded surface ball.

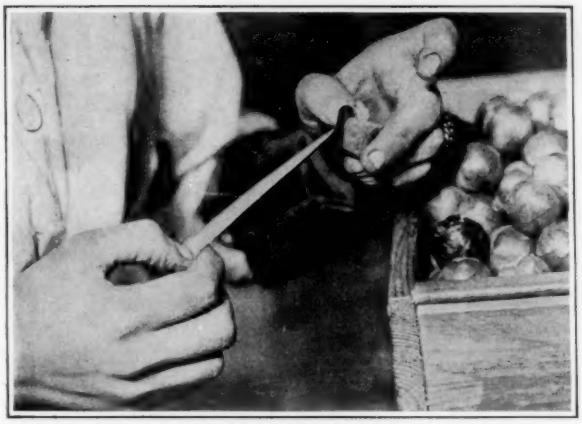
About 1850 a new departure came and it was discovered that gutta percha could be molded into the necessary sphere for the game of golf. Among the first Scotchmen to use this new invention was Wm. H. T. Peter. Naturally many experiments were made with this new form of ball. Some balls were made to go farther by increasing their specific gravity with weights in the center; Mr. Peter found that a small portion of lead made the ball more steady.

THE HASKELL BALL, SHOWING THE RUBBER WINDING AND THE GUTTA PERCHA CORE

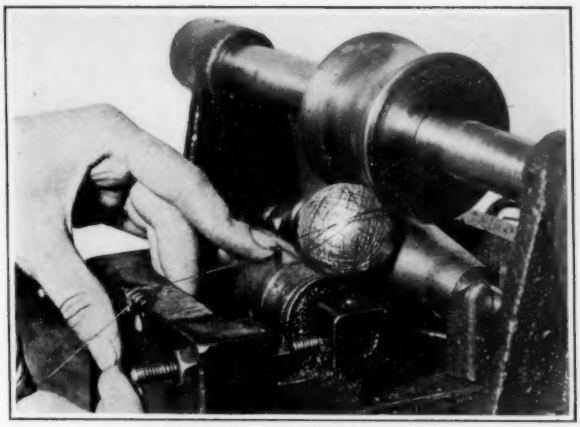
The introduction of the gutta percha ball tended to make golf a more popular game as the new balls could be made much cheaper than the feather ball; but golf had grown up from, and existed among, a very conservative class, and it was some time before many of the players would experiment with this new ball. Then again the new ball had its tricks, and one had to learn how to handle it; there was a good deal of prejudice against it, and one good opposition was that while it started well off the club it had a tendency to "duck." The reason for this was that the first balls were made smooth, *i.e.*, the seams of the old style ball were missing. Gradually it was found by the more persistent users that after a ball had been played with a few times and received several good bangs, particularly with an iron club, it flew better. As scoring seemed to aid the flight, balls were soon made scored; but the scoring was of a crude nature, being done by hand with a chisel and hammer. These hand-hammered balls continued for some years; in the mean time many men became quite proficient in the art of hammering. With the improved conditions feather balls gradually went off the market, and the cheapened ball soon made the game more popular.

After it had been proved scientifically that the matter of scoring lengthened the "carry" and improved the flight of the ball, scoring became the regular thing and was done by the manufacturers in the molding of the gutta percha at the time the ball was formed. Although it took six months to properly season a good "guttee" ball, it was when matured a very serviceable article, in addition to which it was most distinctly an economical ball, for it could, when well worn, be remolded.

For fifty years the solid gutta percha ball with various forms of marking, from the hand-hammered, the line-marked, and later the bramble-marked, held its own, and it remained for the inventive genius of an American in 1899 to give the golfing world another new type of ball. This new ball, the forerunner of many more of a similar nature, was the result of an evening discussion among a few golf enthusiasts in the famous rubber State of Ohio. Among the party was Mr.



WINDING RUBBER TAPE AROUND THE CORE



WINDING ON THE RUBBER THREAD

Haskell afterward of "Haskell ball" fame. Mr. Haskell decided next morning to try out a scheme which he had had in mind, and immediately set to work on a hand-made ball for experiment. The experiment proved quite an encouraging success when tested out at one of the local golf clubs, and it was not long before the world-famed "Haskell" ball was on the market. The new ball was soon the talk of golfers on both sides of the Atlantic, and so great was the rush among inventors to produce new golf balls that within a year almost a hundred applications for patents on golf balls had been filed in the United States alone.

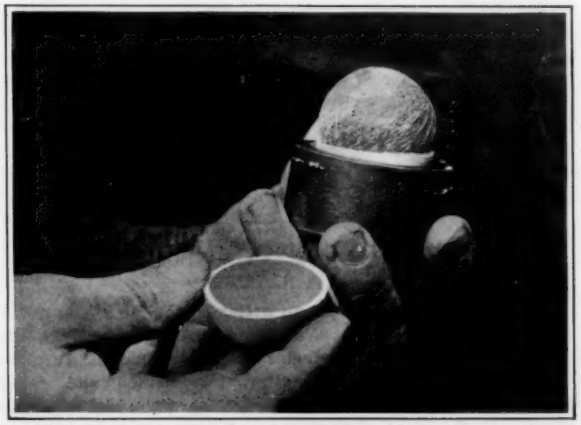
The original Haskell ball was composed of a gutta percha core encircled by thin rubber thread wound closely about the core, and the two substances enclosed by a gutta percha shell; the core was about 40 per cent of the size of the ball, the remainder consisting of the wound rubber and the shell. For quite a time this continued the general principle of construction in the various new balls, the percentage of composition varying, sometimes consisting of a small core with more winding and more thickness of cover, sometimes a larger core, the tables being turned and the conditions juggled to suit the ideas of the various manufacturers. The world was not allowed to rest for another fifty years without further changes and these more particularly on the inside of the ball. Every new ball brought with it a new form of interior—a ball with a small steel ball inside the center core, hollow cores with liquid centers, a ball with a water-filled core, a pneumatic with compressed air in the core, another with a jelly center to the core—but the india rubber thread and outer shell were still retained. These all took their turn on the market, some suiting the style of one player some another.

Although we had advanced many years since the days of the introduction of the gutta percha ball, there were still many who were quite prejudicial against this new invention. The first really important test given the Haskell ball was in the Amateur Championship at Atlantic City in 1901. In this championship twenty out of 124 starters in the qualifying round used the new ball, among them Mr. W. J. Travis of international golfing fame, and always among the first to go into a new venture, and Mr. C. B. Macdonald, one of the early amateur champions of this country. Mr. Travis had naturally not acquired proper control of the new sphere, but he managed to win the qualifying medal with it, and turned in a score of 157 strokes, eventually winning the championship in the match play rounds.

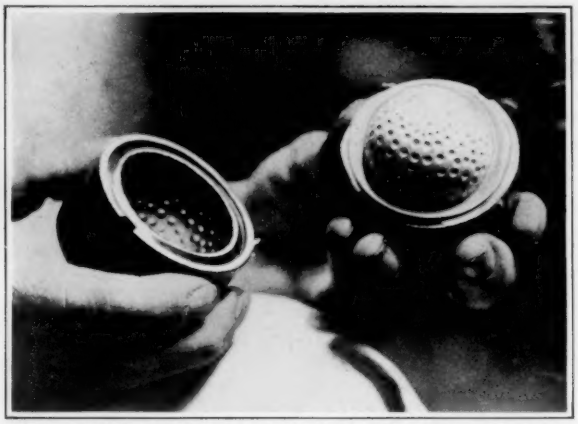
It was not long before it was discovered that although the new ball vastly increased the length of a man's stroke, in all shots it was difficult to control on the putting green and it had the same defect which was credited to the early guttee ball—it "ducked." The reason for this latter trouble was that the first balls made were put out with the shallow lines of the "Silvertown" marking. Through the ingenuity of that skilled golfer, James Foulis, who was then professional of the Chicago Golf Club at Wheaton, Ill., this difficulty was overcome. Foulis conceived the idea, thin as the outer shell was, that the new ball with great care could be remodeled; his venture was a success, and he turned out the ball with a "bramble" marking, which was discovered to give the proper flight; the Foulis remade balls were much in demand until the manufacturers themselves put out the ball with bramble markings, which was, if not better, at least more accessible than the limited remades.

The new ball brought with it, even after players had managed to master all its idiosyncrasies, still more troubles. It was not long before courses had to be lengthened to meet the new conditions imposed upon them by the modern ball. Holes

PREPARING THE OUTER SHELLS OF GUTTA PERCHA



FITTING THE SHELL AND CENTER INTO THE MOLD



THE DIMPLE MOLDED BALL, SHOWING THE "COLLAR" THAT HAS TO BE REMOVED BY HAND

APPLYING A COAT OF PAINT BY ROLLING THE BALLS BETWEEN THE PALMS OF THE HANDS

that had been laid out for the average player and bunkered accordingly were made to look ridiculous; irons came into use where drivers and brassies had formerly done the work, so as to shorten up the stroke, and keep the player out of trouble, for several yards were added to the length of every well played stroke, and whereas in former days a 6,000-yard course had been considered a long one, it was now necessary to add four or five hundred yards to keep pace with the times. In the present day we have settled down to more or less of a standard in balls, for this year we are to have limitations as to weight and size in all tournaments; this has been decided by a joint agreement between those two important governing bodies, the United States Golf Association and the Royal and Ancient of Britain. The ball now must not exceed 1.62 ounces in weight nor measure less than 1.62 inches in diameter; the make and style of marking are matters of choice, and in the matter of marking "brambles" which for some years have been the popular fancy, are now giving way to the more modern "dimple" type. There are hundreds who play golf today to whom the gutta percha ball is nothing more than a thing of history.

The manufacturer of the present ball is of course far more intricate than its predecessors; mechanical processes are added to manual skill. The winding of the center core is carefully started by hand, on the centering of this core depend the entire quality of the finished article; for should this be in the least degree at fault the ball would not travel with accuracy. The fine rubber thread is then wound under tension to a predetermined thickness, accordng to the manufacturer's particular style. The outer shells are fitted over the wound ball, and it is submitted to heavy mechanical pressure in the mold to bring the upper and lower shell in perfect union. This contact produces what is called a "collar," which is carefully removed. But there is one stage of the manufacturing process which still remains as it did in the days of gutta percha production; that is the final painting. Modern ingenuity has not yet devised a scheme for coloring that surpasses that of the hand. Hand painting is still the most successful manner of covering the ball with its coat of white paint. But whatever the ball, whether feather, guttee, or of the present style, golf as a game, fortunately, remains much as our ancestors handed it down to us.

## PAINTS FOR IRON WHICH IS EXPOSED TO HIGH TEMPERATURES

THE following abstract of an article by K. Nicksh is quoted from the February *Journal of the American Ceramic Society:*

"Pure graphite is satisfactory for coatings of furnaces, autoclaves, etc., which are alternately heated and cooled. For good appearance and resistance to very high temperatures sodium silicate has proved efficient. Vessels subjected to even temps. may be protected by a hot application of a mixture of 500 g. of melted lard and 16 g. of powdered camphor with enough pure powdered graphite to give a dark color. The excess which does not penetrate should be scraped off after 24 hours. Cast-iron rust forms a coating which protects the body of the iron from further oxidation. Wrought iron forms no such protective rust but a covering with an iron oxide base, as red ochre, is resistant to acids and fumes at high temps. Walls of furnaces and chimneys where low temps. prevail may be painted with a thin coat of a pitch and tar mixture which has been heated and to which 2 to 3 per cent of milk of lime and a little asphalt has been added. It may be diluted with turpentine. This makes a resistant coating which acquires an excellent luster. "*Durabo*" is a commercial heat-resisting paint which must be preceded by a coat of red lead or iron oxide. Varnishes and drying paints cannot be used, as they crack with temp. changes. Paints should be applied only to perfectly clean surfaces. Previous coats should be removed with 50 per cent carbolic acid solution. Rusted spots should be treated with 5 per cent HCl, followed by a rinsing with a diluted soda solution. After thorough drying the surface should be polished with emery cloth or rotten stone. As base for the paint a thin coat of varnish or linseed oil may be applied.—C. B. Edwards (C. A.)"

## THE SOLUBILITY OF METALS IN AMMONIA

WHILE water is the most widespread solvent, holding in solution the greatest variety of both organic and inorganic substances, it has always been held that metals could be dissolved only in other metals. Recent experiments have shown however that hot anhydrous ammonia will dissolve the alkaline metals and some other metals.

First Weyl and then Palmair have succeeded in obtaining solutions whose color differs according to the metals concerned, being blue in the case of the alkaline metals, green in that of lead and red in that of tin, by the electrolysis of organic salts of these metals dissolved in liquid ammonia, which boils at —33.5° C. According to experiments made by Ruff and Geisel 5.87 molecules of ammonia are required to dissolve one atom of sodium.

The study of the electrical conductivity of the blue ammoniacal solution of the alkaline metals has led Kraus to conclude that the metal is dissociated yielding a positive metal ion and a negative electron. Finally, it has been proved by an optical examination that all the metals which are soluble in ammonia, with the possible exception of calcium, yield the same absorption spectrum. The most plausible explanation of this remarkable fact is that the absorption is due to the circumstance that the electrons change their position, carrying with them molecules of the solvent.—From *La Nature* (Paris), for January 1, 1921.

# The Ballistic Wind*

## French Studies of the Effect of Wind Pressure on Projectiles in Flight

By J. Rouch

Naval Lieutenant, Former Chief of the Meteorological Service of the French Army and Navy

IT may be said without fear of contradiction that before the war the influence of meteorological factors by no means occupied a place in accordance with their importance in the calculation of the flight of projectiles. In those days it was thought sufficient to make measurement (and without any great degree of precision at that) of the temperature, and the direction and velocity of the wind in the vicinity of the batteries. The tables employed did not permit of an approximation at all close of the effect exerted by these factors upon the projectile. The sights were set by trial ranging and little attention was paid to the number of shots fired before the correct aim was found.

The navies, however, have long made a more extensive study of the problem of securing a rapid adjustment of the aim—the quantity of projectiles which it is possible to store upon shipboard, is, of course, very limited and it is important not to waste them; furthermore, in naval battles the man at the gun is not only a marksman but a target, and victory perches upon the banners of those who first hit the mark.

The great development during the war of the use of heavy artillery at the front, led to a similar study of rapid aim on the part of land batteries—the available amount of projectiles was more or less limited and furthermore, the work of air scouts was of great aid in locating the enemy's batteries. It accordingly became necessary to shorten the regulation time and to make the first projectile come as near the mark as possible. This has a double advantage since it makes the work of the scouts easier when the projectiles fall sufficiently near the target to be immediately located. Observation of these matters led to the initial elements of the aim whose study had been somewhat neglected to be regarded with the importance they deserve. Furthermore, the arrival of marine gunners at the front contributed to the increasing application of exact methods of aiming.

In order to make a precise calculation of the initial factors concerned in a good aim, it is particularly necessary to have a knowledge of the influence of the wind. But the exact character of this influence was not then thoroughly fully understood. The range tables habitually employed, even by marine gunners, did not give the corrections required in the function of the wind except in the neighborhood of the ground and entirely failed to indicate the variations of the wind due to altitude. It was not until 1915 that a discussion of the sighting done by various groups of 19's, especially of the 1st and 3rd groups, led to the discovery of the simple and almost intuitive rule which appeared to be sufficiently exact for all practical purposes, that the deviation imparted to the projectile by the wind is proportional to the time during which the projectile is subjected to the said influence.

The application of this rule to the regulation of aiming during a fight or "sighting" was made for the first time at the battle of Artois May 9, 1915, by the first group of 19's. To calculate the influence of the wind it is necessary, therefore, to know the variations of the wind at different altitudes, and to obtain this information sounding balloons must be sent up from stations located near the batteries. It will be remembered that the velocity of the wind at different heights is measured by following the drift of a small balloon with a theodolite. This operation is termed an aerological sounding, but until 1916 only a few of such sounding stations existed; and it was scarcely possible, therefore, to make much improvement in sighting methods because of the lack of sufficient data with regard to the wind. A decisive impulse was given to the latter by Marshal Foch, who was then in command of the armies of the North; in the instructions which I received from him to organize the meteorological service in preparation for the battle of the Somme, the information to be furnished to the artillery was held to be as important as the general weather forecast provided for the air force or the gas companies. During the entire battle of the Somme in 1916 we made it our endeavor to improve the meteorological information designed to assist the artillery and along the battle front the sounding stations newly installed made about twenty aerological soundings per day from June to October. These experimental tests induced the general in command to give orders in October, 1916, to make a general application along the entire front of the methods employed during the battle of the Somme. This was precisely stipulated in the orders sent to the meteorological service October 22, 1916.

But at that time we still adhered in our calculations with regard to the influence of the wind to the rule established by the groups of 19's. Upon the receipt of the reports from the sounding station it was the duty of each battery to calculate the effect of the wind upon the projectile in each stratum of air given, and then to summarize these partial results in order to obtain a total correction. Such an amount of calculation inevitably required a good deal of time, and it was frequently impossible to make it because the length of the portion of the projectiles trajectory in a successive strata of the atmosphere was not known. In such cases the wind which prevailed was taken at two-thirds or three-quarters of the rise of the trajectory without any very adequate reason, and then entered this wind in the tables of correction.

In order to make general the employment of precise directions, it was necessary to discover a rule which should be simple and easy to apply. Making any sort of calculations under the fire of the enemy always seems a rather complicated matter and a man in the thick of the fight finds it a bit difficult to compose his mind to calm scientific observations. The problem was solved by means of a note by Major Taton, commanding the 7th Groups of 32's and by a very complete study of the duration of the trajectory of projectiles in the atmosphere, which was made in January, 1917, by MM. Lebesgue and Montel, members of the mathematical service of the Bureau of Inventions.

Major Taton drew attention to the fact that in the case of projectiles of the 32's, no matter what the charges employed, the durations of the trajectory of the projectiles in the various strata of the atmosphere were practically the same as those obtained by observations of trajectories in a vacuum. MM. Lebesgue and Montel demonstrated that the comparative duration of the trajectory in the successive strata of air were independent both of the caliber of the guns and of the initial velocity and that they depended only upon the rise of the trajectory.

Two projectiles which ascend to the same altitude remain in a given stratum of air during the same fraction of the duration of the total trajectory. It is permissible, therefore, to replace all the variable winds which exert an effect upon the projectile, by a fictitious constant wind which is the same for all projectiles whose trajectory has the same rise. The calculation of a fictitious wind can be made by an entirely different service, *e.g.*, by the meteorological service in charge of wind observations instead of by the artillery.

### THE BALLISTIC WIND

It was on February 10, 1917, that we sent to our armies a first note with respect to the calculation of this fictitious

*Translated for the *Scientific American Monthly* from *La Nature* (Paris), July 24, 1920.

wind, to which was applied the term *ballistic wind*. The ballistic wind was calculated as follows:

Let T represent the duration of the total trajectory of the projectile and small $t$ the length of time during which the projectile remains in a given atmosphere of stratum. If we assume that the effect of the wind upon the projectile is proportional to the time during which it operates, then in each layer of the atmosphere the effect exerted would be proportional to the ratio of $t/T$.

But the factors $t/T$ can readily be calculated in function of the arc or rise of the trajectory since they are the same as for a trajectory *in vacuo*, and these factors are the coefficients which will affect the values of the wind in the successive layers of air.

For example, in the case of a rise of 2,000 m. it would be necessary to multiply the winds observed from 0 to 500 m. by 0.13, those from 500 to 1,000 m. by 0.16, those from 1,000 to 1,500 m. by 0.21, and those from 1,500 to 2,000 m. by 0.50. The geometric sum of these different winds would be the ballistic wind corresponding to all those projectiles having a trajectory with a rise of 2,000 m.

By means of tables very rapid calculations can be made at meteorological stations to determine the ballistic winds corresponding to each rise of 500 m.

The employment of the ballistic wind rapidly came into general use among our armies and this easy correction process met with great favor from most of our batteries. The practical results were found to be excellent as was proved by the very large number of letters from commanders of batteries or groups. I will here content myself with a citation from one written to me by Lieut.-Colonel Gay, commander of the R.C.A.L. Group of the 6th Army on May 18, 1917, following the battles which took place in April:

"The ballistic wind transmitted by the meteorological station or by the sounding stations of the army has been employed in making preparation for the firing of heavy artillery, for the values of the rise of the trajectory comprised in general between 1,500 and 3,000 meters and which have sometimes exceeded 6,000 meters. The precision attained was as follows:

"1. For long guns firing with a rise of approximately 2,000 m.—first salvo generally at less than 100 m. from the mark—it was especially noted that photographs revealed that certain shots by 32's which had to be made without observation because of the prevailing fog, exactly tallied.

"2. Howitzers and mortars of large caliber (rise from 3,000 to 5,000 meters) were found equally exact.

"3. For long guns with very great range (rise from 5,000 to 6,000 m.) the initial deviation was about 200 m. for a total correction of approximately 1,000 m. These results are most excellent, hence the present process of employing the ballistic wind renders the best of service."

Numerous testimonials of the same sort confirm the importance of this new method, and at the beginning of 1918 the Bureau of Marine Service upon the receipt of a letter from a general in chief, summed up these testimonials in the statement that "an extremely important contribution has been made to the attainment of precision of aim in the French armies." An equally prized testimonial came to use in a letter from M. Borel, at that time director of the Scientific Service of the Bureau of War, who congratulated us upon having accomplished this important reform so rapidly.

However the ballistic wind found some critics. The ballistic rule which served as the basis was criticised in these words: "The effect of the wind is *not* proportional to the time during which it acts. The preponderant action is not necessarily the action of the wind at high altitude but may possibly be that of the wind at low altitude."

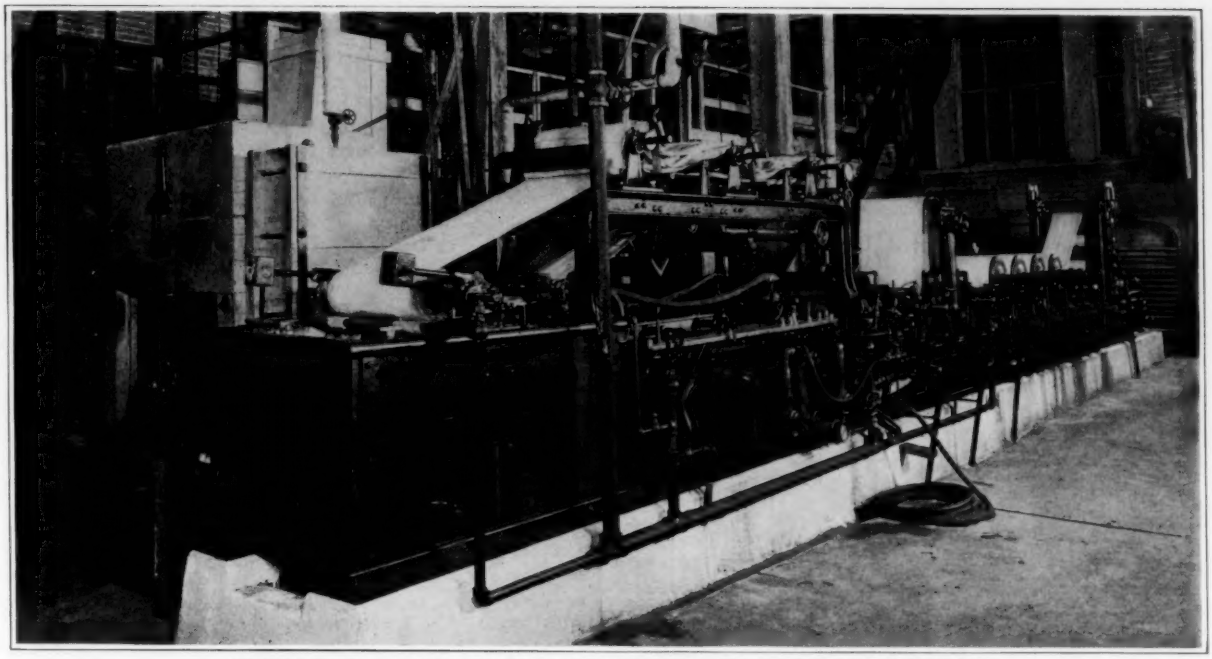
The laborious studies of the commissions upon taking aim in the endeavor to decide the problem did not arrive at the establishment of simple rules until after the end of the war. The intuitive law accepted by the groups of 19's in 1915, continued to be adopted by the great majority of batteries, since it was found that this law permitted the making of marvelously accurate shots. Thanks in part to the ballistic wind, precision of sighting made great progress in the course of a single year, not only in the heavy artillery but also in the light artillery.

We do not mean by this that the present methods for determining the correction of the wind are incapable of being improved. Moreover it does not lie within the province of meteorology to solve this problem of ballistics. The problem solved by the meteorological service may be stated as follows: A law of ballistics being given how can a fictitious wind be calculated which can readily be transmitted to the batteries and applied by them. The actual progress attained consisted in solving this question. Without the ballistic wind there would always have been certain battery commandants, who would have felt constrained to make long calculations to discover the corrections of the wind; but this degree of precision would have been attained only by a minority, whereas when the artillery was furnished with a fictitious wind already calculated it was applied by all the batteries and the general precision of sighting was thus considerably increased. If in the future some other law of ballistics should be discovered, it would be necessary to attempt to state the said law in such a form that the meteorological service, which measures the wind, will still be able to calculate the fictitious wind to be applied by the artillery.

## DISPERSION OF PROJECTILES

INVESTIGATIONS recently carried on as to the dispersion of projectiles, including experiments at Aberdeen Proving Ground, Md., have shown that the dispersion of field high explosive projectiles ranging in caliber from 75-mm. to 8-in., is mainly due to the behavior of the projectile in the part of the trajectory near the gun. It had previously been shown that as the projectile leaves the gun it executes a series of periodic swings similar to the swing of a clock pendulum; the plane in which the swing occurs rotates uniformly; amplitude of the swing in the case of some service projectiles is as great as eight degrees on either side of the trajectory, but it varies considerably from round to round. As the projectile reaches greater distances from the gun, the character of the motion changes from that of swinging back and forth across the trajectory to a type of motion in which the projectile swings or precesses around the trajectory; amplitude of motion decreases until about a mile from a 75-mm. gun the projectile is traveling almost nose on. Resistance of such a swinging projectile is considerably greater than that of one traveling nose on, depending on amplitude of the swing. Consequently a projectile having a large swing near the gun will lose more velocity and have a shorter range. The dispersion, especially at high elevations of the gun, is due mainly to this effect.

In the light of this, the general problem of designing accurate projectiles depends upon three factors: Effect of design of the projectile and twist of rifling upon amplitude of initial swing; effect of shape of projectile on increase of resistance caused by the swinging motion; rate at which the swing dies out as depending on design of the projectile. Considerable progress has already been made in investigation of the first and third factors, and a new chronograph is being installed at Aberdeen for investigations with regard to the second factor, *i.e.*, increase in resistance due to the swinging motion. It has been possible to make comparatively accurate predictions of the relative dispersion of the same design of projectile when fired in guns of different twists of rifling. It is expected that when investigations now under way have been extended, it will be possible to predict approximately the amount of dispersion of a given type of projectile in a given gun before it has been fired. For example, if it were desired to design a projectile and rifling for a 100-mile gun, it should be possible to predict what proportion of the shots would land within a two-mile circle a hundred miles away from the gun.—Abstracted by *The Technical Review* from *Army and Navy Journal*, Feb. 5, 1921.



EXPERIMENTAL PAPER MACHINE AT THE FOREST PRODUCTS LABORATORY

This small machine is equipped with both Fourdrinier and cylinder wet ends and is used in making paper from the experimental pulps cooked at the laboratory.

# Book Paper from Southern Woods

## Possibility of Using Pines and Other Conifers to Furnish a Perpetual Supply of Pulp

By Sidney D. Wells *

THE paper shortage during the past five years has been such that the individual who has not been brought to feel its existence is indeed rare. A great variety of reasons have been given and remedies suggested, and while many of the latter may have a measure of merit, the situation can only be relieved by attacking it from many sides—single or isolated efforts will not suffice. Shortage of wood was the reason most commonly given for the situation; but while some shortage undoubtedly existed a glance at the figures of standing timber, even in the older sections of the country shows that the consumption of wood for wood pulp is but a small fraction of the wood available, and the prices paid for it are much in excess of those paid for wood for other purposes. Why then does the reported shortage exist? A brief outline of the amounts of pulp made in the United States by each of the important processes and the wood requirements will serve to explain. The figures for the year 1918 are taken since no later figures are available.

In manufacturing 1,303,000 tons of mechanical pulp 1,345,000 cords of wood were consumed. The mechanical process usually requires the best quality of pulp wood, since the color and cleanliness of the pulp reflects directly the condition of the wood; for this reason over 85 per cent of the wood used was spruce. Six per cent was made of fir, 4 per cent Western hemlock, and 5 per cent of all other species.

In manufacturing 1,386,000 tons of sulphite pulp, 2,860,000 cords of wood were required. Seventy per cent of this was spruce and fir, 26 per cent hemlock, 2 per cent poplar, and 2 per cent all other species. The sulphite process is not quite so rigid in wood requirements, but manufacturers are not yet using appreciable amounts of resinous woods.

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In manufacturing 344,000 tons of soda pulp 749,000 cords of pulp wood were required. Any wood may be reduced to pulp by the soda process, but the strength of the paper produced is not so great as might be possible using the sulphate process. Consequently, the soda process is used mainly in the production of soft, easily-bleached, short fibered pulps for uses such as book paper where strength is not so important as proper printing qualities. In this process 80 per cent of the wood used was from deciduous trees.

In producing 167,000 tons of sulphate pulp 296,000 cords of wood were used. The sulphate process which is a modification of the soda process, is alkaline in nature and uses similar equipment.

Any species of wood can be reduced to pulp by this process, but because this process is specially adapted to the production of strong pulps, only long fibered coniferous woods are used. The presence of resinous matter in the wood offers no difficulties, and knots and bark are often digested with the wood with satisfactory results. A larger proportion of saw mill waste is used in this process than in any other. The process has only recently been introduced in the United States, and the tonnage at present is comparatively small but it is growing more rapidly than any other.

From the above description it is apparent that of the 3,200,000 tons of pulp annually produced in the United States 2,690,000 tons or 84 per cent is dependent on very few species of wood which belong to the spruce, fir and hemlock families. These species comprise only 11 per cent of the standing timber, as compared with 60 per cent of the standing timber among the pines, Douglas fir, cypress, redwood, larches, and cedars, and 29 per cent among the deciduous species. Table I gives the geographical distribution of species and also shows that the coniferous regions where the pines predominate have by far

the greatest annual growth, which indicates the possibility of a perpetual supply of pulpwood where these conifers can be used.

In considering the possibility of utilizing the pines and other conifers not now used for paper products, the annual production of the different classes is of interest and is given below for 1918:

| | | |
|---|---|---|
| Paper board | 1,927,000 | Tons |
| Newsprint | 1,260,000 | " |
| Book paper | 849,000 | " |
| Fine paper | 368,000 | " |
| Wrapping paper | 714,000 | " |
| Bag paper | 177,000 | " |
| Felts and building | 284,000 | " |
| Other grades | 471,000 | " |

In the above classes of paper unbleached sulphate from the pines and other conifers could be used to advantage in wrapping and bag papers, and as the strengthening fiber to give the necessary strength to the old paper stock which forms the bulk of the raw material in the paper board class.

TABLE I

*Geographical Distribution of Species*[1]

| | New England | Middle Atlantic | Lake | Central | S. Atlantic and East Gulf | Lower Mississippi | Rocky Mts. | Pacific Coast | Total |
|---|---|---|---|---|---|---|---|---|---|
| | % | % | % | % | % | % | % | % | % |
| Spruce hemlocks and firs | 1 | 1 | 1 | .... | .... | .... | 1½ | 6½ | 11 |
| Pines | 1 | 1 | 1 | ⅓ | 7½ | 7½ | 4½ | 7½ | 30½ |
| Douglas fir | .... | .... | .... | .... | .... | .... | 1 | 19 | 20 |
| Cypress and Redwood | .... | .... | .... | .... | ½ | ½ | .... | 2½ | 3½ |
| Tamarack and cedars | ½ | ½ | 1 | ½ | .... | .... | 1 | 3 | 6½ |
| Hardwoods | ½ | 1 | 4 | 10½ | 5 | 7½ | .... | .... | 28½ |
| Total | 3 | 3½ | 7 | 11½ | 13 | 15½ | 8 | 38½ | 100 |
| Annual growth | 8 | 8 | 7 | 5 | 27 | 16 | 6 | 12 | 100 |

Newsprint, however, depends on mechanical pulp and sulphite for its raw material, and book paper depends very largely on sulphite pulp, soda pulp, and reclaimed magazine stock.

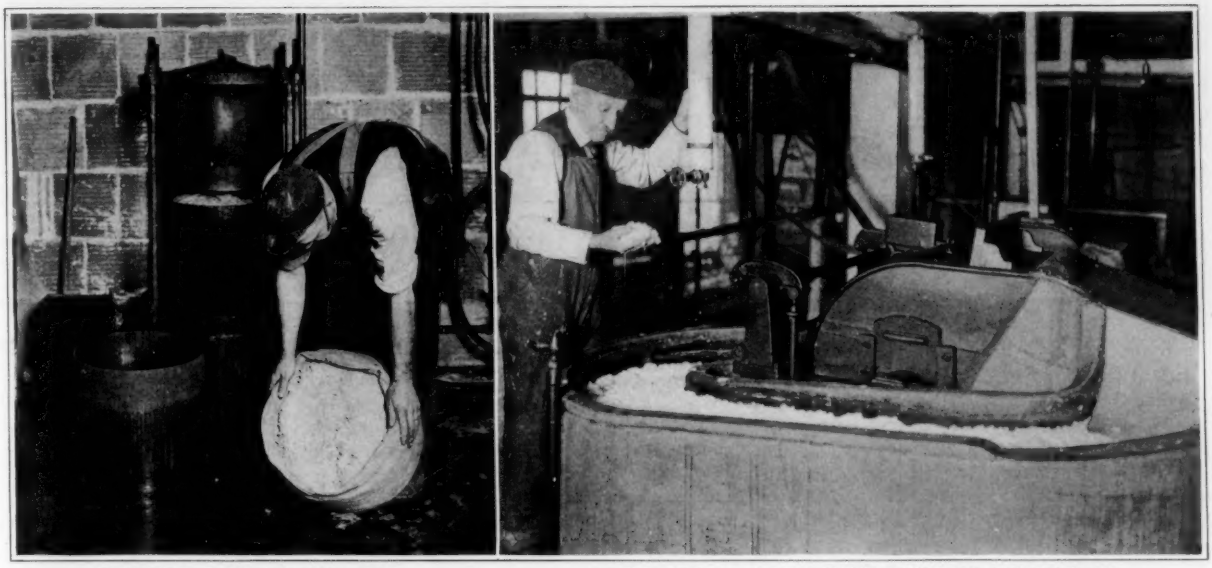
In order to find a cheaper raw material for the manufacture of book paper, with the assurance of a perpetual supply, the use of the Southern pines has often been suggested. So far as the writer knows, however, attempts to accomplish this result have met with failure. Recently, experiments were carried on at the Forest Products Laboratory to determine the possibilities of loblolly pine as typical of the Southern pines together with red gum as a source of bleached pulp for book paper. The results were successful. In this work, the sulphate process was used and was found to give pulps that bleached with reasonable amounts of bleaching powder with higher yields per cord of wood than is obtained from spruce or poplar. The sulphate process is commonly regarded as specially adapted to the production of unbleached pulps but the work referred to indicated that it is far superior to the soda process in the production of bleached pulps from either coniferous or deciduous trees, and with some woods a satisfactory degree of white can be obtained that is impossible with either the soda or sulphite processes. In the manufacture of book paper it is customary to mix a long-fibered stock such as spruce sulphite with a short fibered but soft stock, such as bleached poplar soda pulp, in proper proportions to obtain the necessary strength combined with the proper printing qualities. The strength is obtained from the long fibers of the sulphite pulp while the proper degree of softness, bulk, finish, opacity, etc., is obtained from the soda pulp. All the properties mentioned were obtained by using loblolly pine and red gum in equal proportions, and pulping by the sulphate process.

In this process the wood is chipped in the usual pulp wood chipper to a size of from ⅝ to ¾ inch with the grain and then screened and conveyed to large bins above the digester. The digesters are cylindrical wrought iron or mild steel vessels with conical bottoms, and they are capable of holding from five to fifteen cords of wood in chip form. The chips are run into the digesters with the cooking liquor which consists of a solution of caustic soda and sodium sulphide, the active reagents, and a certain amount of inert chemicals such as sodium sulphate and sodium carbonate caused by the incompleteness of the smelting and causticizing operations, which will be mentioned later. After charging, the digester is sealed and heated by either blowing in high-pressure steam, or by circulating the liquor through a heater on its way from the bottom to the top of the digester. After digestion, which takes from three to six hours at 90 to 120 pounds pressure, the contents of the digester are blown into a cyclone separator and dumped into a wash tank, or blown into one of a series of closed wash tanks called diffusers; and the pulp is washed with water. The spent cooking liquor, called black liquor on account of its color, contains the soda combined with from 55 to 60 per cent of the wood substance. The pulp is run over suitable machines to remove the water used in washing it from the diffusers and is ready for the bleaching operation, or shipment as unbleached pulp. The black liquor is concentrated in multiple effect evaporators, flue gas evaporators, and rotary incinerators from which it immerges as a mass resembling tarry coke. It is then fed into smelters together with sufficient salt cake (crude sodium sulphate) to make up the loss of soda in the recovery cycle. In the smelters, the remaining carbon derived from the wood substance in the black liquor is burned at a very high temperature by means of air nozzles, and the soda compounds in the black liquor are converted to sodium carbonate, while the sodium sulphate is reduced to sodium sulphide. These compounds run from the smelters in a molten condition into dissolving tanks, and, when the solution has the desired strength, it is pumped to the causticizing department where the sodium carbonate is converted to caustic soda by means of quick lime, and the sodium sulphide remains unaltered. The solution of caustic soda and sodium sulphide obtained is diluted to the desired strength and used in cooking the chips as already described.

The caustic soda has a very drastic action in resolving the ligneous and resinous constituents of the wood to soluble compounds and a certain portion of the cellulose (of which the pulp is almost entirely composed) is dissolved with correspondingly lower yields. The sodium sulphide has a similar action on the ligneous matter, only it is about half as drastic. Its strong reducing action furthermore serves to protect the cellulose while the compounds that produce the color in the unbleached pulp, though they exist in extremely small quantities, are rendered more susceptible to the action of bleaching agents.

In digesting wood for pulp which is intended to be bleached, more drastic cooking conditions are used than when pulp is desired that will be used unbleached. The yield of the latter is usually from 42 to 45 per cent of the dry weight of chips used, while the yield of bleaching pulp is usually not over 40 per cent, and, in the case of sulphate pulps from coniferous woods, as low as 36 per cent. In order to bring about the removal of coloring matter, known to be less than 2 per cent of the weight of the pulp, and probably much less, a reduction in the amount of pulp obtained of over 10 per cent based on the weight of the pulp is necessary when using these methods.

[1]Table I was compiled from data and information given in Report on Senate Resolution 311, "Timber Depletion, Lumber Prices, Lumber Exports, and Concentration of Timber Ownership" by the Forest Service, U. S. Department of Agriculture, and "The Lumber Industry" by the Bureau of Corporations, U. S. Department of Commerce and Labor.



DRY PULP TAKEN FROM PRESS
The pulp is pressed after removal from the blowpit. The pressed cakes are much easier to handle

PULP BEATER AT THE FOREST PRODUCTS LABORATORY
Experimental pulp made from waste cotton hull fiber is being mixed with water preparatory to running it into paper.

The waste and costliness of these drastic methods of attaining the results desired were recognized in the experiments under discussion and efforts were made to modify the bleaching treatment whereby yields of pulp as high as 42 per cent could be bleached. It was finally found possible to obtain these results by dividing the bleaching treatment into two steps. From one-third to two-thirds of the bleaching liquor, which consisted of a solution of common "chloride of lime," was added and the pulp circulated for about two hours when the chlorine, the active chemical, was found to be exhausted. The pulp was then washed and the remainder of the bleach added. It was found that the above procedure made possible the bleaching of pulps with yields of pulp as high as 42 per cent with bleach consumptions of from 15 to 20 per cent, while bleaching the same pulps in the customary manner required from 30 to 40 per cent. It is usually considered not feasible to use more than from 20 to 25 per cent of bleaching powder to bleach wood-pulp; and when more is required, the cooking conditions are made more drastic and the yield decreased until the customary bleaching requirements are met. Yields of only 35 per cent would be obtained in producing pulps that could be bleached between 15 and 20 per cent in the customary manner. It is, therefore, apparent that by means of the modified bleaching method the yield of pulp obtainable has been increased over 16 per cent. The method is furthermore one that can be readily adapted to modern bleaching equipment and would not increase the cost of bleaching greater than the overhead, maintenance and power costs entailed by an increase of 50 to 100 per cent in the bleaching equipment. Inasmuch as the strength and color of the pulps obtained are considerably improved, the higher cost would be taken care of by the better quality of the product. The output of the pulp mill would also be considerably increased because not only was the output per digester charge increased 16 per cent, but the time of cooking and amount of cooking chemical required per digester charge was reduced by 16 per cent. In other words, a mill capable of producing 50 tons of pulp per day using the customary method could increase its output to 70 tons per day by using the modified bleaching method, and altering the cooking conditions accordingly.

It has been pointed out above that by the use of proper cooking and bleaching methods economically feasible loblolly pine and red gum can be used as a source of bleached pulp for the manufacture of book paper. Work on most of the other Southern pines, black and tupelo gum, swamp maple and similar woods occurring in sections of the South unsuited for agriculture indicate that they all are substantially as well adapted for the purpose. The prevailing prices of cord wood and mill waste throughout the South would indicate a source of raw material at less than half the cost experienced in the present pulp making centers; and the supplies of spruce, fir, balsam, hemlock, and poplar are rapidly disappearing. Many localities in the midst of plentiful supplies of wood are also favorably located for shipping facilities, in proximity to supplies of coal, lime, salt cake, and other supplies, and there is no reason why the manufacture of bleached pulp and book paper cannot be made profitable provided efficient organizations can be effected. The climate, the fact that the industry would be entirely new to the locality and entail the necessity of employing skilled help accustomed to different environments, and the use of unskilled help unaccustomed to industrial environments are serious obstacles, but notable examples of the successful establishment of other industries indicate large possibilities.

## DISCOLORATION OF METAL

THE *Houghton Industrial Digest* for February discusses sunlight as the cause of discoloration of polished metal parts. An inquirer states that three years ago a new mill was erected and equipped with expensive machinery and special pride was taken in keeping bright parts polished and free from rust. They were polished with waste and rubbed with lubricant oil, but after a time took on a brownish color which, while it did not resemble rust, could not be removed. Examination of the machinery showed that most of the discoloration was to be found upon metal parts exposed directly to the light and where direct rays of the sun could strike the metal, the spots were darkest. Bright parts in semi or complete darkness were unaffected and the conclusion is inevitable that the brown coloration in question is due to the action of the sunlight on the lubricant oils used in the effort to prevent rust. It is probable that the action of light upon these hydrocarbons caused a deposition of carbon and a great liberation of carbon. It is also well-known that various metals have affinity for carbon so that if the hydrocarbon is affected by the light the carbon deposits in the pores of the metal give a brownish stain.

GENERAL VIEW OF ANCIENT OSTIA AND THE TIBER, SHOWING RUINS OF WAREHOUSES

# A New Port for Rome

## The Ancient Harbors of Ostia and Porto on the Tiber

By Albert A. Hopkins
Fellow of the American Geographical Society

THE economic depression resulting from the World War has directed attention to the utilization of forgotten resources. We look to gain wealth from waterfalls and rapids, we try new foods and intensive cultivation, so it is not surprising to find Italy alert to save every lira by reclaiming her barren land and promoting housing in new localities.

Prince Orsini, of the famous Roman family, has succeeded in interesting capital in a scheme of land reclamation of the *Agrum Romanum*—an immense barren tract between Rome and the Mediterranean. This country was once of great fertility and was dotted with castles and villages but they fell a prey to marauders, Saracens and pirates, and then to the more deadly foe, malaria; for the region includes the famous Pontine Marshes. It is a mistake to consider this land as a dreary extent of stagnant, slimy water, traversed by melancholy roads; on the contrary the marshes resemble the rich plains of Lombardy with abundant grass and herbage which grow with a luxuriance which Italy of the North can never exhibit. No roads could be more excellent than those which lead through the marshes, upon which the carriage or automobile rolls along between unending alleys of trees whose thick branches afford a welcome shade from the scorching sun. Canals cross one another and drain off some of the water. Occasionally a solitary post house is passed which shows the effects of the poisonous effluvia which steam up from the marshes. The lime-washed walls are entirely covered with an unctuous gray-green mold. This stamp of corruption follows human beings as well and the peasants are pale yellow and sickly in the extreme.

It is now proposed to remedy all this, for the marshes can be drained and the country made one of the most healthful parts of Italy. This reclamation work will occupy six years and will cost $50,000,000—a large sum for Italy to invest at this juncture, but English and American banks have looked with favor on the project. Once the dread malaria is extirpated, this land would be of inestimable value to Rome and would make the city self-supporting and bring back to the capital of the Cæsars something of its old time glory.

The chief town in the area is Ostia, which, in 50 B. C., was one of the principal cities of Italy, but in the first century it was ruined by the silting up of the port and without modern dredges the case was hopeless. The Emperor Claudius built a new harbor up the Tiber two miles above Ostia; this silted up in a time and the Emperor Trajan built another harbor in A. D. 103 united with the port of Claudius on the west and with the Tiber by a canal. In the 10th century this port became filled up and commerce went to mediaeval Ostia and in 1612 the canal of Trajan was once more cleared out by Pope Paul V. and connected with Fiumicino. Since then this has been the only way by which vessels can ascend the Tiber, the other branch having been almost entirely closed up by sand near its mouth. It is now proposed to build another city near Ostia to relieve the housing situation in Rome, the distance being less than twenty miles. This would give Rome a maritime port which she needs badly, Civita Vecchia being altogether too far away. The engineering charges would be borne in connection with the reclamation work on the marshes.

It would perhaps be worth the reader's while to glance briefly at a short sketch of Ostia, "Porto" as the Claudian-Trajan port is called, and also Porto d' Anzio the ancient *Antium* which was of great commercial and military importance to Rome. It should be noted that this seaport is not on the Tiber but is in the other direction about as far to the south of Ostia as Civita Vecchia is to the north.

The subject of the trade of Rome is an interesting and important one. The metropolis of the ancient world at one time numbered about 1,000,000 inhabitants, and it was no small task to provision this city. Ostia, on the coast of the Mediterranean Sea, now about twenty-one miles by rail from Rome, was naturally the great *entrepôt*. It was settled in the second century after the foundation of Rome, by Ancus

Martius, and soon became an important commercial town. Under Augustus it lost some of its importance, due to the choking up of the harbor by the Tiber. Christianity was introduced at an early date, and the Bishopric of Ostia, according to some accounts, was founded by the apostles themselves. The early Popes were all consecrated by the Bishop of Ostia.

The Tiber at present washes down eight and one-half million tons of sand annually, and this gradual extension of the delta has left Ostia miles inland. The astronomer, Padre Secchi, and Professor Lanciani have determined that the average yearly advance of the coast is about 19 feet.

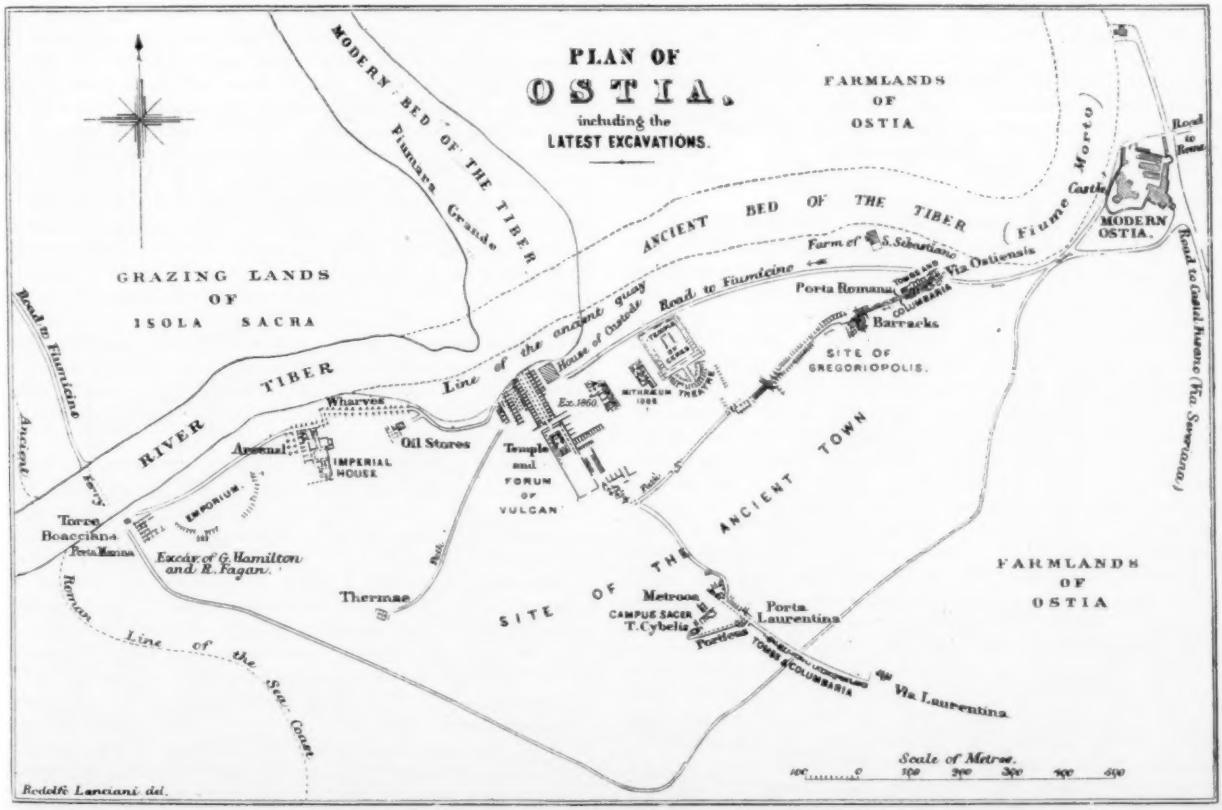
The Tiber was a bad river to navigate, and while an ancient man-of-war could easily get over the bar, owing to its light draught and great propelling power, merchantmen usually had to anchor outside and discharge their cargoes with the aid of lighters. The old Romans made no attempt to improve the harbor, which they could have done very easily, for vessels of 150 tons burden now reach Rome. In early times the vessels were towed upstream by oxen and buffaloes, tow-paths being provided for them. Navigation was not allowed at night and the vessels had to moor at stations. Professor Lanciani states that there were thirty of these stations between Rome and the sea. Vessels from Ostia often reached Alexandria in eleven days and Gibraltar in five days.

At Ostia the warehouses covered one-half of the town, which was two miles long and one mile wide. The city of Ostia must have presented a splendid appearance, as it contained fine temples, theaters, and villas of patricians, and the ruins were so extensive that for five centuries the villagers burned marble for lime without exhausting the supply; and when Poggio Bracciolini visited Ostia with Cosimo de' Medici they found the villagers occupied with burning an entire temple into lime. It is sad to contemplate the loss of so many antiquities, for the rude peasants burned wall facings and statues alike.

Our engraving represents the warehouses along the so-called "Street of Wharfs." The floors are raised three feet above the pavement to facilitate the loading of carts. On the opposite side the ruins seem to belong to the private houses of merchants, the ground floors and basements being used for storage purposes. One of the rooms is in excellent preservation. It is 36 feet long by 28 feet wide, with six rows of large earthen oil jars 4 feet in diameter, each marked with its capacity. Another store belonging to the same house is vaulted over and has two circular openings for light. The barrack of the firemen (vigles) and constables is one of the important ruins of Ostia. These men were numerous, as frays and fires are very apt to occur where large bodies of lawless sailors are congregated.

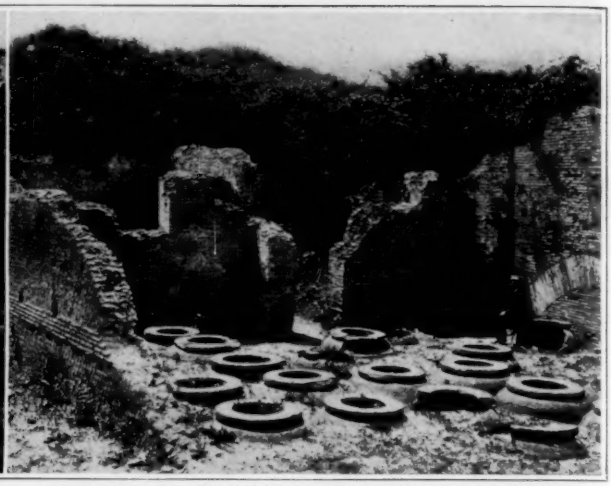
One of our engravings shows a portion of one of the warehouses, and it may also be seen in the middle of another of the engravings. It gives an admirable idea of the solidity with which the Romans built all constructions of this kind. Through the arch to the left may be seen the concrete which was faced with what is known as "*opus recticulatum*," where the stones were carefully cut so as to present a square or lozenge-shaped end, and are fitted very closely one to the other. These little blocks are about 3 inches square and are arranged to run in diagonal lines; the angles of the wall have neatly worked quoins with the inner end pointed so as to work in with the small lozenges. The effect of this sort of facing is very neat, but its beauty seems to have been very largely concealed by stucco. The front walls of the warehouse were built of brick which average 1 foot 11 inches square. The voussoirs are also of brick and the pediment and entablature are admirably handled. The engraving is interesting as showing Roman methods of construction, and also as showing how well the Romans built, even where the structures were used for such ordinary purposes as warehouses.

The harbor which Claudius built two miles up the coast from Ostia was inclosed by jetties. The area of the harbor was about 6,200,000 square feet, and the quays were over a




OSTIA, THE SEAPORT OF ANCIENT ROME, WHICH WAS SILTED UP BY THE TIBER

DOOR OF A MAGAZINE ON THE PRINCIPAL STREET OF OSTIA



INTERIOR OF WAREHOUSE WITH BURIED AMPHORA FOR OIL, WINE, ETC.

mile long. The breakwater was constructed with the aid of caissons. The huge ship by which the Vatican obelisk was brought from Egypt was filled with concrete until it sank, then it was strengthened with rocks until it was above the level of the sea, when it was crowned by a lighthouse.

"Porto," Trajan's harbor, is now two miles inland, and is a shallow lake surrounded by ruins. It resembled in every way a modern port: it was hexagonal in shape, and the basin communicated with the Port of Claudius. Trajan's harbor is one of the most interesting works of Imperial Rome.

Egypt alone shipped 190,000,000 bushels of grain to Rome, and Sicily, Sardinia, and other places poured in their enormous supplies of foodstuffs. In addition to this may be reckoned the vast quantities of building materials, especially marble, which were imported. The Claudian Harbor was also used as a great naval station, and here was also the central post office for foreign correspondence. In modern times harbors have been constructed on even a larger scale than the three harbors mentioned, which successively served to receive the great ocean-borne commerce of Rome, but none of them ever possessed the same magnificence.

We quote from Rodolfo Lanciani's "Ancient Rome in the Light of Recent Discoveries,"[1] as follows:

"The Claudian harbor was not only a commercial, but also a military station, from which emperors and admirals were wont to sail, escorted by powerful fleets on their expeditions to the far-away border lands of the empire. The same harbor contained a central post office for correspondence with the provinces beyond the sea, the existence of which office was revealed for the first time in 1874. Our late King Victor Emmanuel, when undertaking, near the end of that year, some excavations on his hunting estate of Castel Porziano, between Ostia and Torre Paterno, discovered the public square or forum of a village, named Vicus Augustanus Laurentium, mentioned by Pliny the younger as adjoining his famous Laurentine villa. In the center of the square stood the marble pedestal of a statue, raised by the worthy inhabitants of the village in memory of a local benefactor named P. Aelius Liberalis, a freedman of the Emperor Hadrian. As usual, the career of the gentleman so highly esteemed by his fellow-citizens is described in the legend on the pedestal. We are told by it how Liberalis began his career in the finance department as cashier of the branch office for the importation of breadstuffs, which had been established at Ostia as the landing place of the fleets laden with the harvest of all the provinces of the empire. In course of time he was elected to another office, *procurator pugillationis et ad naves vagas*—'postmaster of Ostia and superintendent of despatch boats.'

[1]By permission of the publishers, Houghton, Mifflin & Co.

"Postal institutions, in the modern sense of the word, were not unknown in Roman times. To secure quick and accurate intelligence, even from the remotest provinces, Augustus established, all along the great highways, a system of couriers mounted on swift horses, and stationed at an average distance of seven miles from one another.

"Later on he organized a regular service of mail coaches which seems to have been brought to a higher point of perfection by the Emperor Trajan. These accommodations, however, were reserved for the benefit of government employes—such as cabinet messengers, military officers, governors, and so on—and very seldom were for the benefit of private individuals to whom the privilege of using mail coaches was granted only by the emperor himself, or by the governor of a province. At the same time all the burden of the institution had to be borne by the inhabitants of the villages and towns crossed or approached by the high road; they were compelled to supply horses, mules, and oxen, and to keep the stations in proper repair; in other words, they had to pay all the expenses of an organization from which they did not reap any advantage except the manure from the stables, graciously left them by the generosity of the government. Good, humane emperors did their best to relieve the populace from this indirect heavy taxation. There is a coin struck in honor of Nerva with a legend which signifies that the inhabitants of the peninsula at least had been exempted from compulsory supply of horses. Hadrian and Antonius seem to have met the exigencies of the service with their own purse; and, finally, Severus Alexander transferred permanently the burden from the people to the imperial treasury. The postmaster-general, styled '*praefectus vehiculorum*,' of equestrian rank, was selected generally from among retired cavalry officers; he had under his orders provincial postmasters of inferior rank.

"Such was the state of things as regards the over-land post; regarding the maritime post nothing was known until the inscription of P. Aelius Liberalis was brought to light. His double office of postmaster and master of despatch boats makes it evident that the two things were connected as two branches of the same department. There is no doubt that the *naves vagae* of the inscription were something like the *naves tabellariae* mentioned by Seneca as running in front of the fleet laden with grain from Egypt to announce its arrival at Pozzuoli, or like the *naves speculatoriae*, corresponding to the *avisos* of the modern navy. There is no doubt that, with the combined action of canvas and oars, finely-modeled ships could accomplish as quick a passage across the sea as was usually made in the first quarter of the last century. This is proved, to quote only one argument by the remarkable instance related by Plutarch, in chapter sixteen of his life of Cato, when

to impress the Senate with the necessity *'delendae Carthaginis,'* he unfolded his mantle and showed the astonished assembly a batch of fresh figs which had been gathered on the African coast only two days before."

The harbor system at Ostia was brought to absolute perfection by Trajan. He was the builder of that magnificent inner dock, which, although left fully two miles inland by the filling up of the estuary, still exists in its integrity, and is known, especially among wild-duck shooters, as the Lago Trajano, the Lake of Trajan. It had the form of a regular hexagon, 393,000 square yards in extent, with a line of quays 2,156 yards long and with a constant depth of 18 feet. The construction of Trajan's dock required the excavation and removal of 85,000,000 cubic feet of sand, and the construction of 1,940,000 cubic feet of masonry.

Communication with the sea was of far greater importance to ancient than to modern Rome, and its former facility was one of the chief factors in the attainment of the proud rank held by the mistress of the world. The coast was a favorite resort of the wealthy Romans, as the numerous villas testify; but the deposits of mud and sand left by the Tiber, especially when in flood, have thrown forward the coast line and entirely altered its appearance. It is now desolate, and is skirted by a broad belt of forest (*macchia*), where the malaria in summer is endemic. Lofty sand-hills (*tumoleti*), extending to the south beyond the Pontine Marches, bound the whole coast.

Anzio, a favorite resort of the Romans during the bathing season (June, July and August), in spite of its liability to fever, occupies the site of the ancient Antium.

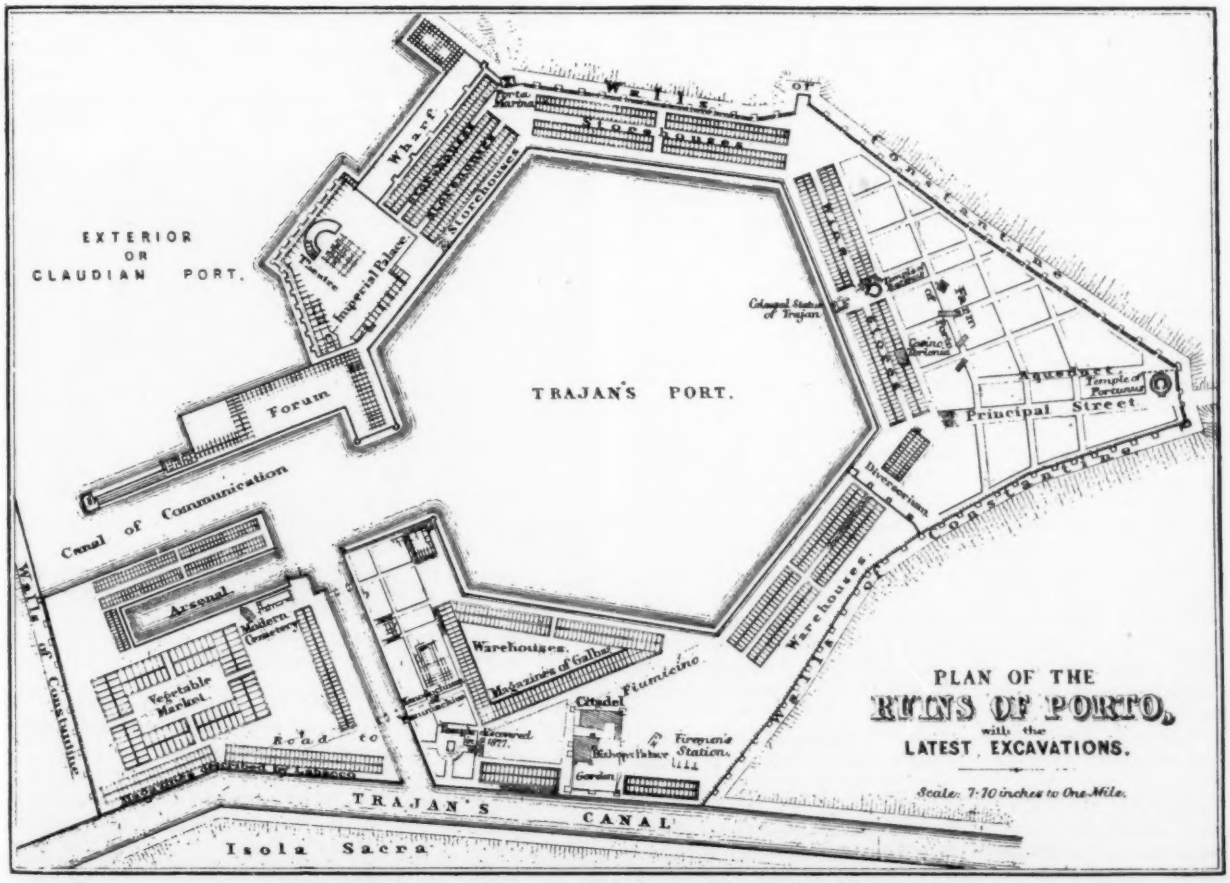
Antium, the capital of the Volsci, and a prosperous seaport at an early period, the place where Coriolanus sought refuge when banished from Rome in 490 B. C. and where he died after sparing Rome at the intercession of his mother, was compelled in 468 to succumb to the Romans. In 338, when all the Latins were conquered, Antium received a Roman colony, and was thus permanently united with Rome. Extensive villas were erected here toward the end of the republic. Cicero possessed an estate at Antium, the tranquillity and charms of which he highly extols. Caligula and Nero were born here; the latter constructed an artificial harbor. Though at a later period Antium seems to have been surpassed in popularity by Baiae and the places on the bay of Naples, the temple of Fortune, mentioned by Horace, where oracular responses were given, existed until the latest era of paganism. The place was entirely deserted in the middle ages, but in the 16th century it began to be rebuilt. The present town dates almost wholly from the period after the restoration of the harbor by Innocent XII. (1698).

The station lies close to the Piazza, and a few paces from the small harbor, which, as it opens to the south, is in continual danger of being sanded up. The remains of an ancient pier may be seen opposite in the direction of Nettuno, near the bathing establishment. Nero's harbor lay to the west of the present one; it was about 150 acres in area and was protected by a jetty of which traces are still visible above the water.

## GREEK TEMPLE OF 400 B. C.

GREEK archaeologists have unearthed an imposing temple at Rerras, Thessaly. The structure is in an excellent state of preservation and is stated to be as large as the temple of Jupiter at Olympia.

The bronze inscriptions establish the date as that of 400 B. C. Tablets have also been found bearing indications of laws and resolutions of ancient civilization. This is the second temple which has been discovered within a month, the first having been found near the city of Volo. The excavations are continuing.




THE HEXAGONAL INNER HARBOR BUILT BY TRAJAN IN 103 A. D.

# Marine Borers in San Francisco Bay*

## Serious Losses to Railway and Other Waterfront Structures Threatened by Teredo

EARLY in 1914 the activity of marine borers was noticed in the dykes of the Mare Island Navy Yard, at the upper extremity of San Pablo Bay, which is the northern arm of San Francisco Bay, as well as at two nearby points on the east shore of that bay. One of the latter was a dock between Crockett and Vallejo Junction and the other a dock at Oleum, a mile or so south of Crockett. Sporadic attacks of marine borers are reported to have been observed in that region at isolated times running as far back as 1870. In any

DOCK AT OLEUM, CAL., WHICH FAILED IN 1919 AND PLUNGED SEVERAL CARS INTO THE BAY

case, these attacks were of short duration and did no serious damage. The waterfront structures erected by the industries were all built on untreated piling, because of the absence of marine borer activity in those waters and the belief that the fresh water discharged into San Pablo Bay from the combined flows of the Sacramento and San Joaquin Rivers would probably prevent any invasion of San Pablo bay by salt water, which would carry with it the various forms of marine borers.

The attack of 1914 appeared to be sporadic, like the earlier ones. But at Mare Island in 1917 attacks by the same shipworm, which was identified as a teredo, again appeared, and during the following years spread very rapidly. In 1920 these failures assumed such proportions and became of such frequent occurrence that the critical nature of the local situation was brought to the attention of the officials of the American Wood Preservers' Association on June 16, 1920. As a result, a special committee was appointed on July 22, 1920, to study the marine piling problem in San Francisco Bay, with instructions to report at the seventeenth annual meeting of the association at San Francisco in January, 1921. The committee began its active work late in July, 1920.

Shortly before June 16, 1920, but practically coincident with the above action, the Forest Products Laboratory of the United States Forest Service at Madison, Wis., had proposed a plan for the study of the marine piling problem covering the entire coastal waters of the continental United States. It was the logical step to unite both proposals, and the San Francisco Bay Marine Piling Survey became, therefore, the first unit of the proposed nation-wide program of the Forest Products Laboratory, under joint coöperation with the American Wood Preservers' Association. The committee was organized with Frank D. Mattos, manager treating plant, Southern Pacific, Oakland, Cal., chairman, and included some 20 engineers connected with industries and railways interested in this problem.

The objects of the survey were to determine the extent of the damage from marine borers in San Francisco Bay, especially that of excessive severity which has occurred within the last three years in the northern portion of the bay; to determine the present distribution of the several marine borers and as much of their past history in the bay as it was possible to learn; to increase the present knowledge of the dissemination, growth and habits of the borers; to study the factors influencing the rate of attack and amount of damage from them, including the effect of climate and river discharge upon the salinity conditions in the bay; to throw more light upon the effectiveness, both in physical life and economic advantage, of the various methods of protecting wooden piling, and of the substitutes for it, together with the best methods of construction which have been developed; and to correct data on the relative costs of the different methods of protection and construction.

The name "San Francisco Bay" is technically applied only to the larger and more important southern arm of the body of water which has its connection with the Pacific Ocean through the Golden Gate. The name is more often used than any other, however, when it is desired to indicate the entire body of water. This larger bay has its longer dimensions closely parallel to the seacoast. It is 52 statute miles in its greatest length in a single direction, and has a maximum width of slightly under 12 miles. The outlet through the Golden Gate is at a point about three-fifths of the total length of the bay from south to north. At a point about one-half of the remaining distance north from the Golden Gate the width of the bay is reduced to a little over one mile, and that point marks the division between San Francisco Bay proper and the upper area known as San Pablo Bay.

At the eastern end of San Pablo Bay there enters a channel known as Carquinez Straits, through which the combined flow of the Sacramento and San Joaquin Rivers is discharged into San Pablo Bay. The Carquinez Straits are from seven to eight miles in length and above them is a large area of water

ACTION OF XYLOTRYA (LARGE HOLES) AND TEREDO (SMALLER HOLES) IN PILE AFTER 2½ YEARS' SERVICE

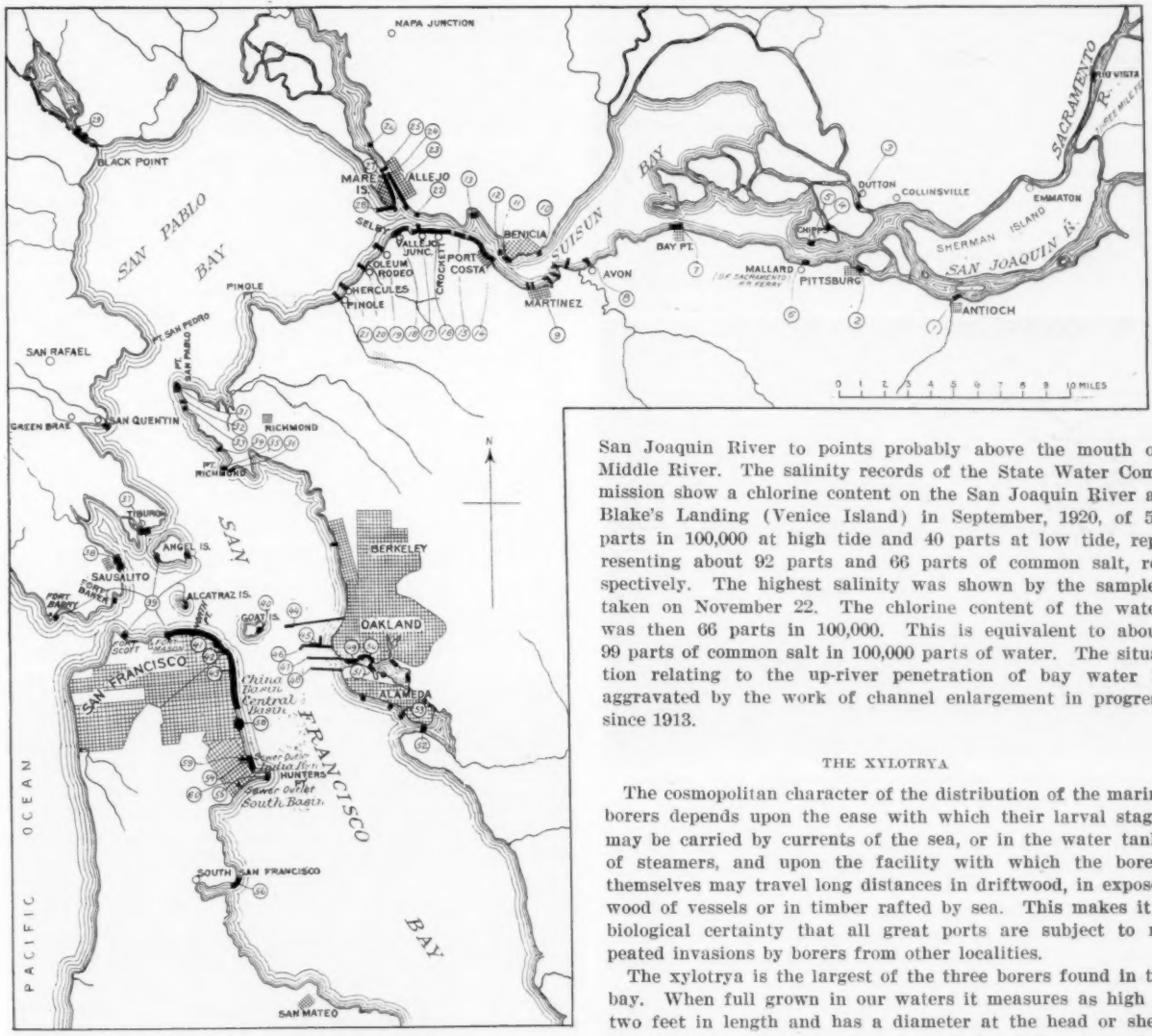
composed of many tidal flats and salt marshes known as Suisun Bay. At a point about 18 miles above Carquinez Straits is the junction of the Sacramento and San Joaquin Rivers.

Destruction from marine borers in San Francisco Bay has been most active in the regions nearest the Golden Gate, where unprotected timber is destroyed within a few months. Destruction is nearly as rapid southward around the San Francisco waterfront. On the Oakland side destruction is

*Abstracted from an elaborate report of the San Francisco Bay Marine Piling Committee of the American Wood Preservers' Association, and presented at the annual convention of that association in San Francisco on January 2. Reprinted from *Railway Age* Feb. 18, 1921.

somewhat less rapid, unprotected piling lasting from 18 months to three years. In the Oakland estuary the activity of limnoria is greater than that of the xylotrya and piling may be destroyed in as short a time as six months.

In the northern area, including the lower course of the Sacramento River, Suisun Bay, Carquinez Straits and the adjacent portions of San Pablo Bay, many of the piling structures, although built wholly of untreated wood, had stood from 30 to 40 years. The destruction there since 1917 by the teredo has been swift and unusually severe. Every waterfront structure as far upstream as Antioch has been attacked by the teredo. This year (1920) the waters of Suisun Bay had




MAP OF SAN FRANCISCO BAY

reached their maximum salinity about the middle of September and, a few weeks later, particularly after the winter rains commenced, the increasing flow of the rivers accelerated the freshening of the water in the upper end of Suisun Bay, so that by the middle of November the brackish water had there been displaced. The seasonal rainfall at the end of December (July 1 to December 31, 1920), has been about 40 per cent in excess of the normal. At the time of greatest salinity during 1920 the bay water at Collinsville, just below the mouths of the two rivers, at high tide, slack water was about one-half ocean water; and at low tide slack water somewhat less than one-third ocean water.

During the low water period of these recent years the irrigation draft upon the Sacramento and San Joaquin rivers was increasingly heavy, largely due to rice growing in the Sacramento Valley, and there was a period of several months of the year 1920 during which it seems to have been a fact that more water was used for irrigation on the delta lands of these rivers than was supplied to the delta channels by the two rivers. In such circumstances some of the bay water which entered the mouths of the rivers on each flood tide was retained in the river channels and caused bay water, under the influence of tidal action, to get up stream at high tide to points in the Sacramento River somewhat above Isleton and in the San Joaquin River to points probably above the mouth of Middle River. The salinity records of the State Water Commission show a chlorine content on the San Joaquin River at Blake's Landing (Venice Island) in September, 1920, of 56 parts in 100,000 at high tide and 40 parts at low tide, representing about 92 parts and 66 parts of common salt, respectively. The highest salinity was shown by the samples taken on November 22. The chlorine content of the water was then 66 parts in 100,000. This is equivalent to about 99 parts of common salt in 100,000 parts of water. The situation relating to the up-river penetration of bay water is aggravated by the work of channel enlargement in progress since 1913.

### THE XYLOTRYA

The cosmopolitan character of the distribution of the marine borers depends upon the ease with which their larval stages may be carried by currents of the sea, or in the water tanks of steamers, and upon the facility with which the borers themselves may travel long distances in driftwood, in exposed wood of vessels or in timber rafted by sea. This makes it a biological certainty that all great ports are subject to repeated invasions by borers from other localities.

The xylotrya is the largest of the three borers found in the bay. When full grown in our waters it measures as high as two feet in length and has a diameter at the head or shell-bearing end of three-fourths of an inch. Tubes over three feet in length and seven-eighths of an inch in diameter have been found in old piling on the San Francisco waterfront. Its burrows differ from those of the two species of teredo found in San Francisco Bay in two important particulars. They are larger and they present continuous minor deviations from the straight or curved course which teredo pursues. Their burrows are therefore less symmetrical and regular than those of teredo. The burrow of xylotrya enters the pile at right angles to the surface as a small pin hole and turns obliquely, usually downward, enlarging rapidly within two inches of the surface to one-quarter inch and within four inches to three-eighths to one-half inch. It does not restrict its course to sap wood, and in cases of sparse seeding of the

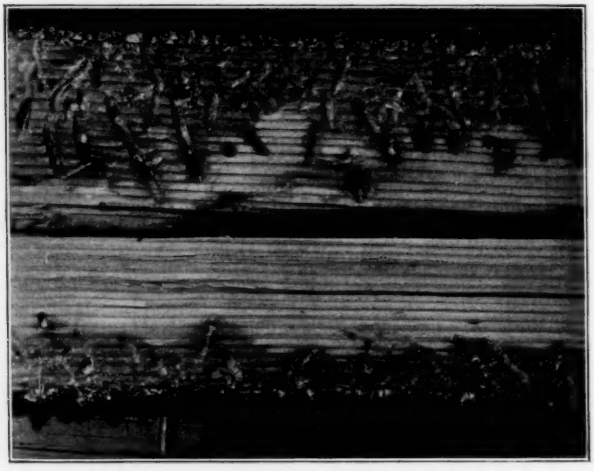
borers, often bores obliquely deep into the wood before turning to run with the grain of the timber. For this reason surface samples may not reveal lightly infected piling.

Xylotrya is generally found in association with limnoria in our waters and the two invade the pile together, although it is probable that when once limnoria gets possession of the surface, xylotrya has a small chance to get into wood. However, creosote-treated piling hollowed out by limnoria sometimes has a few xylotrya at work within creosoted shell but not traversing it.

The rate of growth of xylotrya under existing conditions in the bay is seen in the fact that piles in the dolphin off the Alameda Mole, driven in February, 1919, were so weakened at the mud-line, mainly by xylotrya, that they had to be removed in November, 1920, that is in about 20 months. Piling in the neighborhood of the Golden Gate last only six months, owing to the combined action of xylotrya and limnoria. In so far then as our data go, it appears that the principal molluscan borer to be guarded against in the main and lower parts of San Francisco Bay and on the ocean front where salinities are those normal to the sea or approach it is xylotrya.

### THE TEREDO

The teredo navalis is the ship-worm of the dykes of Holland. This species is the medium-sized species of the three molluscan



PENETRATION OF TEREDO FOUR INCHES INTO GREEN DOUGLAS FIR PILE IN FOUR MONTHS

borers occurring in this region. It is, when full grown in the autumn, from 4 to 10 inches in length, generally 6 to 8, and the diameter of the head end is from ¼ to ⅜ inch. The body lies in the burrow which enters the pile horizontally, and generally, but not always, turns downward at once and expands within one or two inches to a nearly uniform diameter throughout the rest of its course.

The tubes or burrows of teredo differ from those of xylotrya in our timbers in being smaller and somewhat more thickly set or crowded. They enter the piling less deeply than xylotrya, whose burrows, whether few or many, are wont to enter the pile even to the center, while teredo enters deeply only by reason of crowding. Moreover, xylotrya works in shallow water less readily than teredo. When crowded the burrows are often only ⅛ inch in diameter. The burrows enter by minute holes 0.008 inch in diameter when first made, but enlarged to as much as 0.03 as the animal grows older. The burrow runs a curved or straight course, often with the grain and downward when not crowded, or more or less obliquely across it when crowded.

The burrows twist and turn to avoid crossing each other and the direction of the tube may even be abruptly reversed in a short turn, or the inner end abandoned and a new course established at a point above it. They are generally straighter or more regularly curved, and have smoother walls.

The degree of destruction of the timber by excavation is a function of the density of settlement and penetration. In piling with a fairly heavy infection from Port Costa, we find that in four samples the average per cent excavated was 45.5 per cent. In densely attacked timber, the percentage of excavation will run somewhat higher than these figures.

In December, 1919, it was found that teredo had penetrated the piling of the Southern Pacific slips at Port Costa and Benicia two to three inches, and in some instances had almost completely eaten the pile through at the mud-line. A pile pulled at Vallejo Junction in June, 1919, and sawn in two-foot sections, did not contain teredo, nor was it found in surface sampling at low tide on Southern Pacific structures in the upper bay in June, with surface salinities of 3.3 parts per 1,000, but was detected in great numbers on October 15, 1919, in surface and bottom salinities of 22 parts per 1,000, at Vallejo-Junction when a steamer broke off some piling, and shortly thereafter at Port Costa and Benicia, in surface salinities of 12.1 and bottom of 17.6 parts per 1,000, in pulled piling. By the autumn of 1920 they spread up stream until they had reached Antioch on the San Joaquin, 25 miles above Carquinez Straits and 50 miles from the Golden Gate, and up the sloughs of the Delta to Dutton.

This progressive invasion was the direct result of the continued shortage in the annual rainfall and run-off during these years, which permitted the settling of the larval stages on unprotected piling during the breeding season of midsummer and the survival of the borers in the wood during the brief season of the spring freshets of these years. In the upper bay from Pinole through Oleum, Mare Island, Vallejo, Crockett, Port Costa, Venicia, Martinez, to Mococo and Avon, the destruction of piling by this teredo in the summer of 1920 reached a climax which left little or no untreated piling undamaged and not a little of it wholly destroyed by penetration to the center or near it, at the mud-line.

In the meantime the invasion had spread elsewhere to unprotected structures, such as those above Black Point on Petaluma Creek, to the wharves at Richmond, and to the unprotected piling of the dolphins of the Alameda Mole, to some points in the Oakland Estuary, to the Bay Farm Island Bridge, and to the Dumbarton cut-off at the southern end of the bay. It was also found during the survey at South San Francisco, in the Bay View sewer outlet, and at the sewer outlet at Hunter's Point, in new piling in the boom at Islais Creek, and sparingly at Pier 7 on the San Francisco waterfront in treated piling which had been opened up by the attack of limnoria. From the distribution thus shown it is to be inferred that all unprotected piling in San Francisco Bay may be expected to show upon examination an attack by this borer.

### THE LIMNORIA

In addition to the molluscan borers attacking marine structures described above, there are three others belonging to the crustacea of general distribution, namely limnoria, sphaeroma, and chelura. Limnoria and sphaeroma only have been found as yet in San Francisco Bay. These borers owe their efficiency as destroyers of wood to their powerful biting jaws by which they cut their way into the hardest of wood. They both belong to types of crustaceans adapted to life in the zone of extreme environmental conditions, between tides where moisture, light, salinity, temperature, food supply, and stabiliy of the substrate are subject to rapid and extreme change. The body of the limnoria is small, the largest individuals attaining a length of ¼ inch and one-third as wide. It is elongate slipper-shaped, flattened dorso-ventrally, and has rounded ends.

Limnoria is found on both the Atlantic and Pacific shores of the United States, north to Bering Island, and has been reported on European coasts from the Adriatic to Norway. It is common along the California coast in piling on the ocean

front. In San Francisco Bay it is very destructive in the Golden Gate, on the Oakland and San Francisco waterfronts, at Dumbarton cut-off and at Sausalito, Tiburon and Richmond. It was not found north of San Quentin and San Pablo Point and took no part in the invasion of the Upper Bay with teredo. It is thus abundant where salinity is not much reduced by fresh water.

Limnoria destroys piling by gnawing its interlacing branching burrows into the surface of the wood. We have found from 200 to 240 burrows per square inch in heavily attacked timber. These burrows are from 0.050 to 0.025 inch in diameter and follow the softer zones of spring growth between the more resinous harder zones of the annual rings. Piling infested by limnoria thus has an outer scurf of ⅛ to 3/16, rarely ¾ inch of perforated somewhat laminated wood, which is readily broken or falls away as the attack proceeds. In square timbers the attack progresses rapidly between the harder zones of the annual rings on radial sections, leaving these resinous strips as projecting ribs.

The borer is particularly insidious in its attacks upon creosoted piling because of its habit of creeping into small crevices. If cracks open through the saturated zone of a creosoted pile or if bolt or dog holes or peavy holes or other breaks in the continuity of this protection occur, limnoria is sure to find its way into the retreat thus offered and to begin its destructive work. It will reduce such a pile to a mere shell. It is sometimes found in such piles actually at work in the creosoted zone itself. Whether it does this because it slowly becomes acclimatized to the repellent substance or because of defective creosoting, low grade oil, or progressive leaching out of the toxic elements of the oil, is unknown.

The proportion of the wood removed by limnoria in its burrows is somewhat less than that removed by teredo. Teredo-eaten piling has a firmer consistency because of the thicker partitions between the burrows. Limnoria-eaten wood is more friable or spongy because of the numerous small burrows and the more or less elastic resin zones left somewhat intact by these borers.

A test of the average amount of excavation in five pieces of Douglas fir squared timber eaten by limnoria from Tiburon showed an average of 42.8 per cent. The considerable number

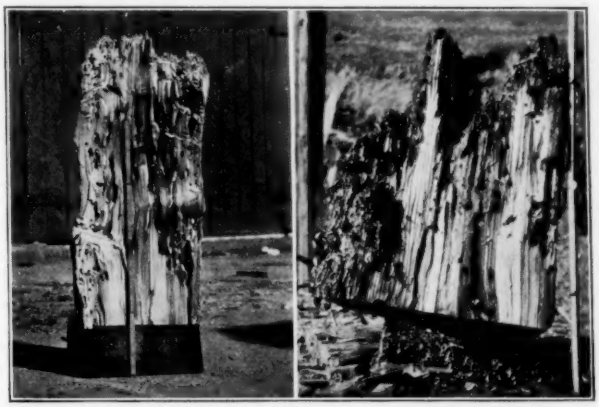
FAILURE OF A CORBEL ON PILE CUT OFF TOO CLOSE TO WATER, BARNACLES INDICATE HIGH WATER LINE

of borers remaining in the burrows somewhat reduces the apparent volume of the excavation. The probability is that it is often in excess of 40 per cent.

### THE SPHAEROMA

The sphaeroma is a larger, stouter form than limnoria, but with the same general structure. The body is broadly ellipsoidal in outline seen from above with rounded ends. It is one-half inch long and one-quarter inch wide and rolls up into a ball about a quarter of an inch in diameter when disturbed. Its color is dark olive to slightly reddish brown. It is often mottled or blotched with lighter dull yellowish areas on the middle of the back. The eyes are prominent and lateral in position.

Sphaeroma is very often found in crevices or other shelter-



SECTION OF UNTREATED DOUGLAS FIR PILE; 7 YEARS' SERVICE

PILE BROKEN FROM PIER AFTER 2½ YEARS' SERVICE

ing nooks outside of its burrows and is evidently something of a forager. It does not appear to depend upon the wood eroded from its burrow for food, for its stomach contents are made up of the minute vegetable and other growths which cover the surface of the piling.

The excavations made by sphaeroma pentodon in marine structures are very characteristic in size, distribution and location. They have circular openings up to nearly one-half inch in diameter, enter the wood horizontally or turn more or less abruptly and run with the grain in the softer layers of the wood. They do not exhibit the expansion characteristic of the molluscan burrows.

Sphaeroma works mainly between high and low tide, though found at all levels on piling. Its workings are obscured in deeper water by the more intense activities of limnoria and the growth of other marine organisms. Between tide levels it gives to the piling a pitted appearance with its large, open, dark-colored burrows. Its work is erratic in that often only certain piles are subject to its attacks while neighboring ones may be untouched. It sometimes runs channels on the surface of wood, especially in the more deeply submerged piling.

The sphaeroma has a wide range of distribution in our locality. It has been found at Sausalito, Tiburon, Black Point, the Mare Island dikes, in Napa Creek, along Carquinez Strait and upstream to Antioch in water of low salinity. It also occurs along the western water front and Oakland Estuary and in the southern part of the bay to South San Francisco and the Dumbarton cut-off. It is known to occur northward to Alaska.

### EXTERIOR INDICATIONS OF MARINE BORERS

The crustacean borers work upon the surface of submerged wood and leave an open record of their destructive activities in the erosion caused by their burrows. Limnoria and chelura erode so rapidly that few other forms of marine life can obtain, or long retain a foothold on the wood in which these borers are working.

As regards the molluscan borers, the case is different. They enter the wood as minute larvæ and leave only a pinhole to mark the places. There is nothing to indicate to the casual observer either their presence or the degree of destruction which they have accomplished.

The survey of the Sacramento River to Sacramento brought out the fact that certain forms of marine life had gone up the river as far even as Walnut Grove, and that these same forms were luxuriantly thriving on piling attacked in Carquinez Straits, as salt water had invaded that territory. They serve, therefore, as indicators to the uninitiated that the sea with its fauna is invading new territory. These marine organisms are the barnacles and the hydroids. The former are well-known crustaceans encased in an armor of shelly plates which cover piling, rocks, ships' bottoms, and any available substrate with hosts of more or less close-set, whitish, angular bodies ranging up to a hazel-nut in size. The hydroids are moss-like plant-animals which form a grayish or brownish mass or, when dead, hair-like growth over piling.

There is fortunately another marine animal of cosmopolitan distribution, the European edible mussel, mytilus edulis, whose somewhat angular black shell is attached to rocks, piling and any stable or floating substrate. The occurrence of young mussels on marine piling is a danger sign for the engineer to look out for teredo.

There is one outstanding feature of the present outbreak of marine borers in San Francisco Bay and of this survey which affects State and Federal supervision of navigable waters and of shipping and engineering practice in the construction and maintenance of marine structures, such as wharves, moles and piers. It is this, namely, that within the area infested by marine borers all unprotected woodwork is a potential breeding ground for harboring these pests, increasing their numbers, and sending forth their migrating larvæ. In every case an infected bit of wood is a contagious spot. A single infected pile in 25 feet of water and its 100 square feet of surface affords shelter for upward of 150,000 teredos, and each of these is capable of producing more than 2,000,000 larvæ per year. Each pile, barring the death rate of larvæ, thus produces enough young to seed 2,000,000 other piles.

### THE ENGINEERING PROBLEM

To the engineer responsible for the design, construction and maintenance of structures in sea water, accurate information on the relative cost and the permanence of various kinds of piling and pile protections is of the greatest importance. After describing the various methods of protecting piles in some detail, the committee concluded that:

(1) Marine borers are very active in San Francisco Bay, and in places where their attack is severe will destroy untreated piling in as short a time as six to eight months. In other places the untreated piling may last two to four years.

(2) The information secured indicates that it is reasonable to expect a life of five to eight years from paint and batten protections if the work is well done. If it is not well done or if the covering is damaged by careless handling this range of life cannot be expected.

(3) When carefully handled so that there is no injury extending through the shell of treated wood within the water section, it appears possible for properly creosoted Douglas fir bearing piling to give a life of 25 to 30 years in San Francisco Bay.

(4) Most of the attack on creasoted piling by marine borers, which the committee has observed throughout this survey, appears to have begun in spots where untreated wood has been exposed by damage in handling the piles or placing the superstructure. It is urgently recommended that improvements be made in the methods of handling creosoted piles and building structures upon them, so that damage to the surface of the piles may be reduced to a minimum.

(5) Precast reinforced concrete piles and pile casings have not been in use in San Francisco Bay a sufficient length of time to determine their ultimate life. A detailed examination of those structures which have been in service for 10 years shows no evidence of deterioration and they seem capable of a long further life.

(6) Cast in place concrete pile jackets and cylinders may be expected to give satisfactory results if properly constructed of suitable materials. The difficulties of this type of construction, however, are of such a nature that the probability of securing a maximum length of life is less than in the case of precast concrete piles or pile coverings.

(7) The selection of a type of piling or pile protection for a given structure must be made upon the basis of cost and permanence of the materials under consideration, the character of the structure and the probable need for future alterations to meet the changing requirements of commerce. When a comparatively short increase over the life of green wooden piling is sufficient, the surface protections will often be found economical in waters not exposed to severe storm action; if a moderately long physical life approximating the average economic life of marine structures in this harbor is desired, a good creosote treatment will provide it at the lowest annual cost so far as present knowledge goes; if conditions warrant building for the greatest permanence, with less regard for first cost, concrete construction may be useful. For the protection from further damage of wooden piles already in place and showing attack by borers, not yet severe enough to require condemnation, the concrete casing, precast or poured in place, is the only means of salvage so far found by the committee.

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## YACCA GUM INDUSTRY OF SOUTH AUSTRALIA

PRIOR to the war the gathering and shipping abroad of South Australian yacca gum was an important industry on Kangaroo Island, just off the south coast of this state. As Germany was the largest user of this product, the industry was suspended during the first years of the war, and not until use had been found for it in the United Kingdom and in America during the latter part of 1916 did the production revive. In 1919 more than 10,000 tons were gathered, and as the Australian consumption is small the greater part of the output was shipped to Great Britain and to the United States. It is believed, writes the U. S. Consul of Adelaide, that further experiments in the use of this valuable product may develop a larger scope for its utilization and thus encourage the expansion of the industry at Kangaroo Island.

Before the war nearly two-thirds of the Australian output was bought by German firms. Local dealers have never been able to discover what use the Germans put it to, but it is believed that it was used in the manufacture of furniture polish and lacquer for metal ware. It should not be overlooked, however, that the product contains a high percentage of picric acid on nitration, and it it is not unlikely that it was also used by the Germans in the manufacture of explosives—a use to which it was put by the Allies in 1917 and 1918.

The gum from the species *Xanthorrhoea Hastilis* is, of course, one of the oldest known sources of picric acid, yielding about 15 per cent by treating the gum with strong nitric acid. The gum has also been used in the manufacture of dyes. To quote a technical report on the subject, "the high yield of picric acid on nitration and of paraoxy-benzoic on alkaline fusion indicates a chemical constitution for the resin of an oxygenated benzine derivative, and among such derivatives are numerous fine chemicals in daily use, viz., photographic developers and material used in the preparation of synthetic dyestuffs. The resin is also said to be of considerable importance in the manufacture of linoleum."

Experiments have shown that the gum is soluble in alcohol, but insoluble in turpentine, linseed oil, benzine, molten paraffin, and hydrocarbon solvents generally. The gum is partially soluble in cold strong sulphuric acid to a deep red solution; on dilution of the sulphuric acid solution and cleaning the brownish red solid separates. When filtered and freed from the sulphuric acid, this solid dissolves in water and is reprecipitated from its aqueous solution by the addition of a little sulphuric acid.—From the *Journal of the Royal Society of Arts*, March 25, 1921.

# Errors of Direction Finders*

## Influence of the Horizontal Parts of the Sending Antennae

By Dr. E. Bellini

IN the early period of the existence of the direction-finder it was generally thought that a well-constructed direction-finder apparatus, installed upon a homogeneous stretch of land and free from local influences, would give exact bearings. Experiments confirmed this idea. At that time, spark transmitters and moderate wave-lengths were used, and, since amplifiers had not then been discovered, the distance at which a station could be located was limited.

But the discovery of the amplifier, which enormously extended the range of the direction-finder, and the adoption of undamped waves of very great lengths, completely changed the working conditions of these apparatus. The satisfaction of being able to reach enormous ranges was counterbalanced by the dissatisfaction at finding a new source of errors, errors

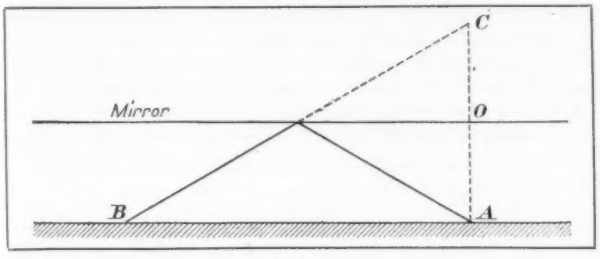



FIG. 1

which could be attributed neither to the conditions of the earth's surface nor to the influence of neighboring bodies. The characteristics of these new errors are their magnitude and their variability. Minimum in the day time, they become larger at sunset and reach their maximum at night, becoming sometimes enormous, as much as 50, 60 and even 90 deg. There rate of change may reach several degrees per minute.

### THE CAUSE OF THE ERRORS

The cause of these errors has been attributed by Round,** Howe,[1] Hoyt-Taylor[2] and others to the reflection of the waves from the highly rarefied conducting strata of the atmosphere (Heaviside layer), and by Eckersley[3] to the reflection of waves from the irregularities in the Heaviside layer. In this article I hope to demonstrate that these errors are due both to the reflection of waves from the Heaviside layer, considered as homogeneous and continuous, and to the influence of the horizontal parts of the sending antennæ upon the horizontal parts of the receiving loops.

At night time the upper strata of the atmosphere are certainly conductive because of the rarefaction, while the low strata are insulating, owing to the absence of causes of ionization. The waves are reflected from the upper strata, and they, consequently, travel in the insulating medium comprised between two conductive surfaces (earth and Heaviside layer).

In the day time the light of the sun ionizes the lower strata of the atmosphere. The difference in conductibility between the upper and the lower strata of the atmosphere tends to disappear and the transmission approaches the theoretical conditions of a homogeneous medium through which the waves travel. The bearings obtained in the day time must, therefore, be in closer agreement with those obtained by theoretical considerations than those obtained at night.

### DETAILS OF EXPERIMENTAL WORK

During the war a large amount of experimental work on direction finding was carried out. The most important observations and facts, which can be utilized for finding an explanation of the errors, may be summarized as follows:

(*a*) Errors are much larger at night than in the day time.

(*b*) In southern latitudes larger errors are generally obtained than in northern latitudes.

(*c*) Waves sometimes appear to come at the same time from different directions and to be shifted in phase, so that the minimum may be ill-defined or even non-existent.

(*d*) Errors are larger for long than for short waves. In particular, the bearings of the Horsea arc station, taken on the marking or on the spacing waves, differ by 30 deg. (Round).

(*e*) Errors are larger for continuous-wave than for spark stations (Round, Hoyt-Taylor).

(*f*) Errors do not exist when the distance of the located station does not exceed about 15 miles (Round).

(*g*) Some stations practically give exact bearings, both in the day time and at night. Round mentions the station of Hanover (Eilvese) and that of Malta, when located by direction-finder stations situated in England.

(*h*) Two transmitting stations placed side by side, but with differently shaped aerials, give different bearings (Round).

(*i*) A sending station utilizing a loop aerial gives different bearings according to the angular position occupied by the loop (Round).

The facts cited under (*d*), (*g*), (*h*) and (*i*) clearly show the influence of the form and excitation of the aerial of the sending station. The mere difference in conductivity of the different strata of the atmosphere cannot, therefore, account for all the facts observed.

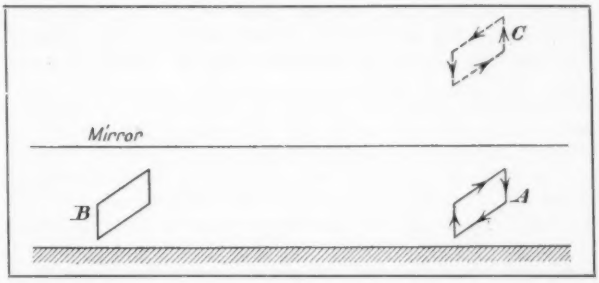



FIG. 2

### AN OPTICAL ANALOGY

The reflection from the Heaviside layer can, at a first approximation, be compared with that from a horizontal reflecting mirror placed some kilometers above the earth's surface. We can apply, therefore, the ordinary rules of geometrical optics. The receiving station *B* (Fig. 1) will receive not only the waves directly sent from the sending station *A*, but also those sent from an imaginary station *C* placed behind the mirror on the perpendicular *AO* to it, at a distance $OC = OA$.

Let us suppose a sending loop *A* (Fig. 2) and a receiving loop *B* parallel to each other. If the reflection phenomena

*Reprinted from *The Electrician* (London), Feb. 18, 1921.

**Captain H. J. Round. "Direction and Position Finding." *Journal of the I. E. E.*, March, 1920; *The Electrician*, Vol. LXXXIV., p. 217, March 19, 1920.

[1]Prof. G. W. O. Howe. "The Upper Atmosphere and Radio Telegraphy." *The Radio Review*, May, 1920.

[2]Lieut.-Commander A. Hoyt-Taylor. "Variation in Direction of the Propagation of the Long Electromagnetic Waves." *Scientific Papers of the Bureau of Standards*, No. 353, Nov. 29, 1919.

[3]Cited by Round, *loc. cit.*

were not present no reception should take place, both because the sending loop $A$ does not radiate toward the receiving loop $B$ and because this is unable to pick up energy sent from a station placed in the direction $BA$. The Heaviside layer acts as if an imaginary sending loop, situated in the same vertical plane as $A$, existed at $C$. The plane of this being inclined to the direction $CB$ at an angle less than 90 deg. will send energy to $B$; and the plane of this, being inclined at the same angle to the direction $BC$, will pick up a fraction

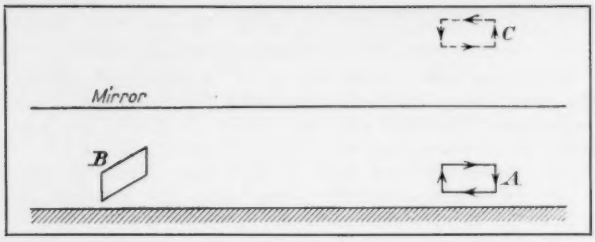



FIG. 3

of this energy. If, therefore, the receiving loop $B$ is swung so as to determine the direction of the impinging waves, a bearing with an error of 90 deg. will be obtained. If the sending loop $A$ (Fig. 3) is directed toward the receiving station B, the action of the image $C$ will give the same direction as the loop $A$, and the bearing will be exact.

In the general case, the plane of the sending loop is inclined at a certain angle to the direction $AB$. The plane of the image will be inclined at a certain angle to the direction $CB$.

The receiving station will, therefore, receive at the same time the waves sent by $A$ and those sent by its image $C$. The electromagnetic field at $B$ will, in consequence, be the resultant of two fields of different directions and of generally different intensities and phases; it will, in general, be an elliptical rotating field. The minimum may, therefore, be good, broad, or non-existent; and if possible to obtain a bearing at all the result will be more or less inaccurate.

### TRANSMITTING STATION WITH VERTICAL ANTENNA

Let us consider now a transmitting station provided with a vertical antenna $A$ (Fig. 4). The Heaviside layer acts as if another vertical antenna $C$ existed in the space and were contained in the same vertical plane of $A$. Both will give the same bearing at $B$ and no errors will be found. The results are different if a horizontal sending antenna is con-

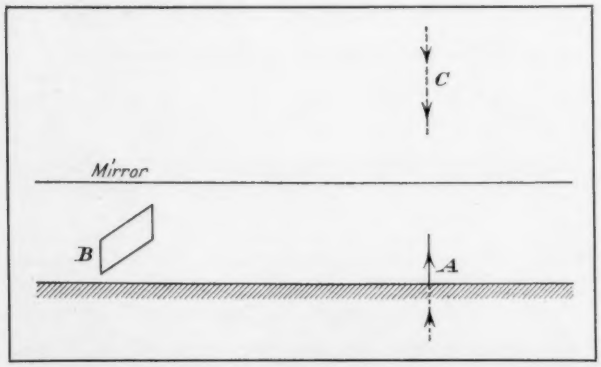



FIG. 4

sidered. If this is perpendicular to the direction $AB$ (Fig. 5) it will not directly affect the receiving station $B$, but the radiation from its image $C$ will be received at $B$ and an error of 90 deg. in the bearing will be observed. If the horizontal antenna is directed toward $B$ (Fig. 6) its image $C$ will be received at $B$, but the bearing will be accurate.

It appears, therefore, from the above-examined particular cases that it is the influence of the horizontal sides of the sending antennæ upon the horizontal sides of the receiving loops that produces errors in direction finding. And as these errors depend upon the angular position of the sending loops, the fact cited under ($i$) would be explained. If a transmitting station is exclusively provided with one or more vertical antennæ, directive or otherwise, no errors should be observed. For instance, the directive sending station $A$ (see Fig. 7), the aerial of which is formed of two vertical antennæ a fraction of wave-length apart, should according to this theory give no errors.

On the contrary, if the antenna of the direction finder could be so formed as to contain no horizontal parts, no errors in the bearings should be observed, independently of the fact that the aerial of the sending station contains or does not contain horizontal parts. In particular, the system of double loop employed by Weagant[4] as an X-stopper and the special receiving loop due to Franklin[5] (used alone, not in connection with an ordinary loop) should furnish exact bearings.

### THE AIRPLANE EFFECT

The Heaviside layer acts, therefore, by producing what Round calls the "airplane effect," which means that the image of the sending station acts as an airplane station high in the sky. Consequently, the methods which have been employed for eliminating the errors in the bearings of airplane stations should be valuable for eliminating the errors in the bearings of stations on the ground.

It is known that an ordinary airplane antenna is strongly

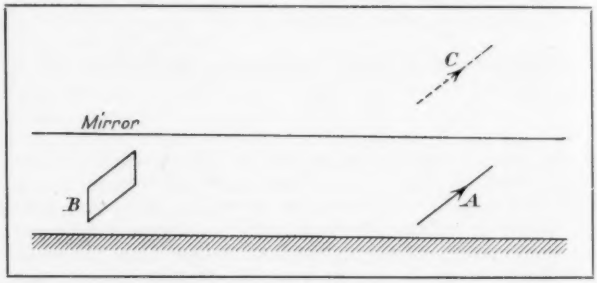



FIG. 5

directive, because it is of the form shown in Fig. 8. It is a kind of Marconi bent antenna. The bearings furnished by such an airplane antenna are wrong except when the airplane flies toward or from the direction-finding station; positions in which the action of the horizontal side is nil. Experiments have shown that if the action of the horizontal projection of the airplane antenna is eliminated, which in this case means that a non-directive antenna is employed, all errors disappear and the bearings become exact (Baldus and Buchwald[6]). This fact appears to be an indirect confirmation of the present theory.

### CONFIRMATION OF THEORY

A direct confirmation would be given by the observations of the bearings of transmitting stations with rigorously vertical antennæ or with antennæ containing horizontal parts. The former stations should give exact bearings, the latter inexact results. We are able to verify the exactitude of the theory only for the station of Hanover (Eilvese). Round observed that the bearings of this station are exact. And as it is provided with an umbrella antenna,[7] which is equivalent to a vertical antenna, it verifies the theory. Round has also found that the Malta station furnishes exact bearings. Lacking

[4] R. A. Weagant. "Elimination of Strays in Wireless Telegraphy." Proceedings Inst. Radio Eng., June, 1919, and *The Electrician*, July 25, Aug. 1 and Aug. 8, 1919.

[5] C. S. Franklin. "Uni-Directional Transmitting Systems," *Wireless Age*, June, 1919.

[6] R. Baldus and E. Buchwald, "Versuche über drahtlose Antheilung von Flugzeugen," *Jahrb. d. Drahtl. Tele.*, March, 1920.

[7] A. S. M. Sörensen, "Wireless Station at Eilvese (Hanover)," "E.T.Z.," May 22, 1919.

information about the antenna of this station, it is not possible to ascertain if it verifies or not the present theory.

According to this idea, it is not surprising that almost all the long-wave stations furnish inaccurate bearings. As a matter of fact, the antennæ of these stations are almost all of the Marconi bent type. They must, therefore, give bad bearings except in the particular cases where the directive finding station is in the vertical plane containing the horizontal part

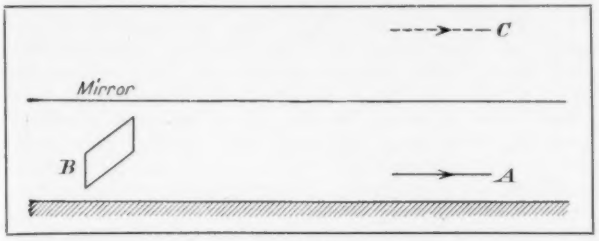



FIG. 6

of the antenna. The observed fact that long waves furnish the more inaccurate bearings than short waves can be equally attributed to the circumstances that for long waves the type of antenna adopted is the bent antenna, the horizontal side of which is longer the longer the wave. To the same cause may be attributed the fact that continuous waves give larger errors than spark stations, as continuous waves are generally longer than spark waves.

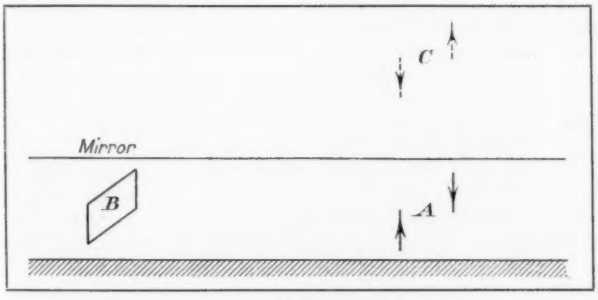



FIG. 7

THE HORSEA ERRORS

The phenomenon observed in the Horsea arc station, which furnishes different bearings when the marking or the spacing wave is utilized, may be attributed to the fact that the current distributes itself differently in the antenna according to the wave-length used; the action of the horizontal side will, therefore, be more or less pronounced in comparison with the

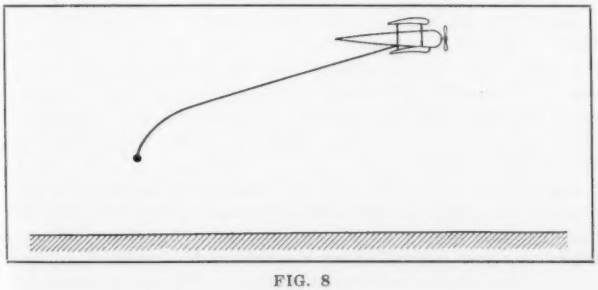


FIG. 8

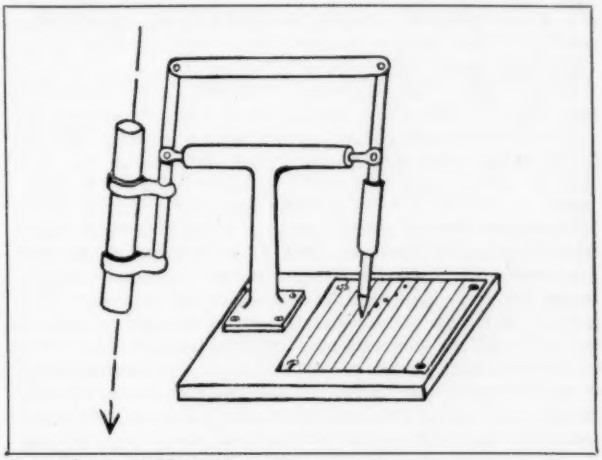
action of the vertical side, according to the wave-length used. If the transmitting and the receiving stations are not too far from one another, the action of the image, which is presumably very high in the sky, may become negligible in comparison with the direct action of the transmitting station, so that errors can be small or non-existent. In this manner the fact that when the located station is not farther than 15 miles its bearings are accurate, whatever the type of the sending aerial may be, can be explained.

This rough sketch of a new theory requires further experimental proofs before it can be accepted or rejected. In the event that it were recognized as accurate, it would have as its first practical result that it would be obligatory to revert to the original Marconi antenna or to its equivalents in transmitting stations destined to serve as beacons for directional wireless telegraphy.

## THE DRIFTOGRAPH

THE French scientist, M. Le Prieur, presented to the French Academy of Sciences, at its session of October 18, 1920, a new method of aerial navigation, an abstract of which we take from *Le Génie Civil* (Paris) of November 6, 1920.

The route corrector with which we are here concerned affords a solution of the general problem of aerial navigation by dead reckoning, *i.e.*, that which consists in moving in a straight line from one point to another by automatically correcting the divergence due to the wind, the pilot being provided, of course, with a compensated compass. This apparatus is based upon the observation of the drift at two different quarters. A graphic record of these two drifts instantly enables the observer to determine the force and direction of the prevailing wind, the path to follow being then readily deduced.



Courtesy of *Aeronautical Engineering*

INSTRUMENT FOR DETERMINING THE DRIFT OF AIRCRAFT

*Determination of the Drift.*—The sole method hitherto employed consists in observing the ground through a network of parallel wires which is oriented in the direction of the apparent displacement of points upon the ground. But this method, which is entirely theoretical, meets in practice with serious difficulties due to rolling, pitching, and more particularly to yawing or lurching.

M. Le Prieur determines the drift by means of an auxiliary apparatus, the "*driftograph*," which shows the average drift by means of a graphic record and thus eliminates the causes of error mentioned above.

The pilot observes any point whatever upon the ground by means of a sighting tube or telescope. The telescope is connected by means of a parallel link motion with a pencil which may be pressed at will upon a sheet of paper placed upon a horizontal board. Every time the point coincides precisely with the hair lines of the telescope the observer presses upon the pencil: in this manner he draws a dotted line which faithfully registers the relative displacements of the aircraft and the ground. The more accentuated the rolling, pitching and rocking the more sinuous the nature of the line drawn, but it is always inscribed without hesitation, or tentative efforts, and the average direction of the drift is deduced merely from the general trend of the dotted line. Evidently this operation requires but a brief time. Even when three or four

points on the ground are sighted to obtain the desired information, not more than a couple of minutes are needed to find the average drift within approximately one degree.

The observer may also operate as follows:

Let us suppose that the recording board is placed, not horizontally, but vertically, and in a plane perpendicular to the axis of the craft, the observer being placed upon the axis and facing the rear. If he now sights the horizon he will trace a horizontal line; if he then sights the axial plane of the aircraft (the tail of the latter) he will trace a vertical line. This being done, if he next sights points upon the ground he will obtain dotted lines which will all cut the line of the horizon at the same point which coincides with the vanishing point of the parallel lines represented by the relative displacement of all points upon the ground with respect to the observer. The divergence between this point and the vertical line will exactly measure the drift, thus affording a new method of determining the drift and consequently the corrected route. This method is particularly valuable when the ground itself is hidden by clouds but when a few points along the horizon are still visible.

*The Route Corrector*—When the aircraft has navigated two different quarters in succession the drifts obtained by means of the driftograph enable the observer to trace upon a circular sheet of paper marked with the compass points and kept in a fixed position by means of the compass, two straight lines and a line drawn from the center of the sheet to the lines. Intersection of these lines gives the velocity and direction of the "prevailing wind."

In this manner the direction of the wind is determined in less than 5 minutes and the corrected route is at once deduced. It is transmitted automatically to a repeater operated by a flexible shaft and placed under the eyes of the pilot.

SUMMARY

To sum up the matter this method which was very conclusively tested on August 28, 1920, in an airplane flying from Villacoublay to Melun and back, affords a prospect of navigating the air under conditions of admirable security. It is possible to register the variations of the prevailing wind in the strata of air traversed and immediately to deduce therefrom the required corrections of the route. For this purpose it is only necessary to discern points upon the ground without having to identify their position upon the map. For over-sea trips small clouds of phosphorous fumes can be employed, set off at regular intervals. These form landmarks which are easy to see.

The safe functioning of the apparatus is not dependent upon any sort of delicate mechanism. It is always ready for use—in short, the graphic method which it employs makes it possible to control the course of navigation and to furnish valuable meteorological data.

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## BALLOON RACING—A GAME OF PRACTICAL METEOROLOGY

By RALPH H. UPSON

METEOROLOGY is no more an exact science than medicine is. To be sure, there *are* laws and principles that can be implicitly relied upon, but the great bulk of our future development for some time to come must depend on the accumulation and coordination of plain *facts*, *experience*, and *practice*. The performance of any aircraft (whether heavier- or lighter-than-air) is a resultant of two factors: (*a*) The power plant of the craft, and (*b*) the surrounding air, or broadly speaking—the weather.

As in other branches of science, the best way to study this important subject from a practical standpoint is to separate it as far as possible from outside influences which only disturb the observations and confuse the result. The free balloon is almost ideally suited to our present purpose for the following reasons:

1. Having no motor, its control is entirely dependent on coordination with existing weather conditions. The performance of a balloon is like that of a free particle of air with the addition of altitude control.

2. The entire freedom from pitching, vibration, noise and wind, permits the most delicate observations to be made.

3. Its simplicity and safety of operation makes a balloon especially desirable for a great variety of experiments. A free balloon is so safe that it is *practically* fool proof.

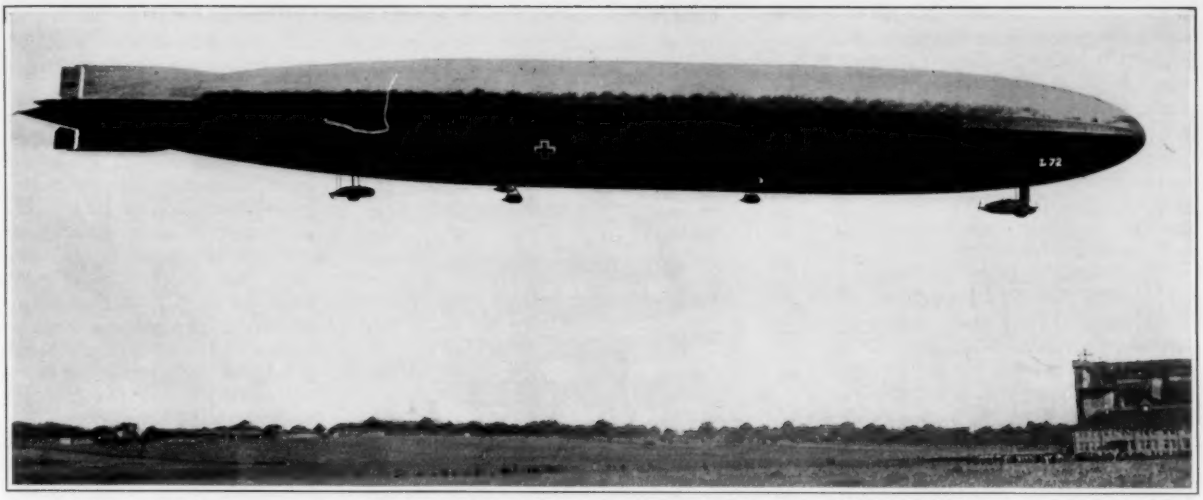
The highest art of ballooning finds expression in the national and international races for distance which are held every year. These commonly run anywhere from 400 to 1,200 miles' distance and 18 to 60 hours' duration. Having been a loser myself in the last big race, I need not be at all bashful to say that one of these races will draw on almost every talent that a man has—knowledge of navigation and meteorology, experience in its application, ability to size up the actual conditions, good judgment in their interpretation, practical skill in handling the balloon, firmness in adhering to a good plan of action but always with eyes and mind open for a better one, courage or caution where necessary, and plenty of plain physical endurance without forgetting good sportsmanship; these are a few of the qualities one can use to advantage in a balloon race. Of the nine international races for the Gordon Bennett cup since 1906, Belgium has been winner once, France once, Switzerland once, Germany twice, and the United States four times. This year the races will start from Belgium because of the Belgian lieutenant, de Muyter's, victory last year.

The history of balloon racing up to the present time shows conclusively that it is taking on more and more of a meteorological character. In the past, races have been occasionally won by mere practical skill in operation of the balloon, but the time when this is possible is rapidly passing, if indeed it has not already passed. In the future, meteorological knowledge instead of being a secondary factor in the assets of a team, will be absolutely the controlling factor.

The record of the race from Birmingham, Ala., last fall is a very interesting study in this connection. The winner was a trained meteorologist besides being a good balloon pilot. His performance in that race sounds almost incredible, but the facts cannot be avoided. He, the winner, among all those who really stayed in the race, landed the very earliest. All started from Birmingham, Ala., between 5:30 and 6 P. M., October 23. At 9:30 A. M. of October 25 the winner was landing in the State of Vermont, while most of the other balloons were floating gently over Indiana and Michigan. One of these (we need not mention names) had ballast in plenty for another 24 hours, but would have needed twice that length of time to reach the distance marked off by the winner. At 2 o'clock in the afternoon (of the third day) a landing was finally made near Detroit, at approximately the same spot that the winner had passed over about 16 hours before.

These are striking coincidences, it must be admitted, but there is plenty of other evidence at least as strong showing the great importance of meteorology in modern balloon racing. And the shoe fits both ways. Not only does balloon racing need meteorologists for its best development, but meteorologists need the experience and stimulus which free ballooning is best able to give.

Ballooning is by all odds the best practical training for anyone who would use weather knowledge. Then why not for professional meteorologists? To be perfectly frank, ballooning is no longer important for the making of structural experiments from an engineering standpoint. The more definitely practical types of aircraft, such as airships and kite balloons, have reached a point where they are no longer dependent on free balloon experience for their structural requirements. But the keen struggle of wits against weather and the wonderful spirit of adventure which is an intimate part of even the shortest balloon flight, will always keep alive this fine sport.—Abstracted from the *Monthly Weather Review* Jan., 1921. Article written Feb. 25, 1921.



THE L.72 ZEPPELIN—ONE OF THE LARGEST RIGID DIRIGIBLES EVER CONSTRUCTED BY THE GERMANS AND TURNED OVER TO THE ALLIES AFTER THE ARMISTICE

# German Airship Construction During the War

## The Remarkable Development of Germany's Aerial Armada During the Period of Hostilities

By Ladislas d'Orcy

FEW efforts in the history of world armaments may be said to parallel in their intensity the creation of the airship fleet by the use of which Germany intended to become supreme in the air and so attain the mastery of the world. Despite repeated setbacks, involving huge monetary losses, to which the war added severe casualties, the forging of this weapon went on unabated for ten years—till the armistice spelled the doom of Germany's mighty aerial armada.

The magnitude of this effort may be appreciated from the fact that between 1908 and 1918 Germany launched and commissioned a total of 140 war airships, of which number 14 were at hand when the war broke out and 109 were built during the period of hostilities. Of the latter all but three airships were of the rigid type and of a size vastly exceeding anything the Allies produced in this line, the capacity of these vessels running from 800,000 cubic feet to 2,400,000 cubic feet, the horsepower from 630 to 2,000, the maximum speed from 52 m.p.h to 77 m.p.h., and the useful load from 9 tons[1] to 52 tons.

The constructional features of these ships as well as their production figures formed a strict secret during the war and the Germans even succeeded in withholding much valuable information until recently. As a consequence much of the data published hitherto on this subject is only approximately accurate, while some of it is absolutely inaccurate. The accompanying tables, having been compiled from reliable German documents, afford the first precise information on Germany's airship construction and airship losses during the war.

Table I shows the principal constructional features and performances of all the airships used by the German Empire during the war. It strikingly illustrates the means by which our late enemies attempted and achieved improved performance, now by adding a gas cell, now by increasing the horsepower, now by lightening the construction, until, having exhausted every possible means of improvement for a given type, they were forced to seek further progress in a much larger type of ship. And as soon as the latter would pass its acceptance tests and be put into production, the same process of detail improvements would be applied to it.

As a result of this policy which was applied only to the rigid Zeppelin and Schutte-Lanz ships—the number of basic types was kept down to a minimum and airship construction became strictly a production problem. With reference to the Zeppelin airships it may be seen from the table that there were actually but three production types, namely, those having a diameter of 49 feet, 61 feet and 79 feet, respectively, the Z.XII-L.9 class being an experimental one. The advantages of this system from the viewpoint of production are particularly obvious in the case of the Zeppelin airships, where the framework is composed of punch pressed duralumin rails and webs which are assembled into triangular girders. As these girders run longitudinally and transversely, the latter forming on the 79-foot diameter type a number of 25-sided polygons, the importance of having a minimum of standard parts becomes evident. This is further emphasized by the fact that each gas cell—that part of the framework comprised between two or three polygon frames—is braced by a large number of diagonal and radial wires, for which again a standard length is desirable.

Another reason which prompted the Germans to adopt a small number of standard diameters was the limit in height of their airship sheds. It is a curious fact that even the Germans—who are often assumed to foresee everything—did not think far ahead enough to provide housing facilities for the inevitable increase in size of their airships. They built, it is true, sheds wide enough to hold two ships side by side, but for their larger Zeppelins these sheds were not high enough. As a consequence, all through the war the Germans experienced much inconvenience in concentrating Zeppelin squadrons and many of their ships were lost through fire or collision owing to crammed quarters and restricted maneuvering space in front of them. Thus, on one occasion, four of their largest and most modern airships were destroyed by a fire which started in the big shed at Ahlhorn, while at another time two ships collided and burnt up in attempting to enter the Tondern shed.

During the war the Germans strove with all their might to remedy this situation by building additional sheds, but in fact this work never kept up with their airship production,

[1]Throughout this article the tonnage of airships is expressed in long tons (2,240 pounds).

TABLE I. GERMAN AIRSHIP CONSTRUCTION, 1914-1918

| Type | Year | Number Built | Length Feet | Diameter Feet | Capacity Cubic Feet | Number of Gas Cells | Useful Tonnage | Number of Engines | Total Horsepower | Number of Airscrews | Speed m. p. h. | Ceiling Feet | Crew | Service |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *(a) Zeppelin Airships* | | | | | | | | |
| Z. IV | '13 | 2 | 462 | 49 | 688,000 | 16 | 8.2 | 3 | 540 | 4 | 48 | 6,500 | 14 | Army |
| Z. VI | '13 | 1 | 488 | 49 | 739,000 | 17 | 8.8 | 3 | 540 | 4 | 46 | 6,500 | 14 | " |
| Z. VII | '13 | 2 | 514 | 49 | 780,000 | 18 | 8.9 | 3 | 540 | 4 | 45 | 7,000 | 14 | " |
| L. 3 | '14 | 6 | 521 | 49 | 794,000 | 18 | 9.2 | 3 | 630 | 4 | 52 | 8,000 | 14 | Navy |
| Z. IX | '14 | 6 | | | | | | | | | | | | Army |
| Z. XII | '15 | 2 | 531 | 52 | 883,000 | 15 | 12.2 | 3 | 630 | 3 | 50 | 9,500 | 14 | " |
| L. 9 | '15 | 1 | | | | | 11.1 | | | | 53 | 9,000 | 14 | Navy |
| L. 10 | '15 | 5 | 538 | 61 | 1,126,000 | 16 | 16.2 | 4 | 840 | 4 | 60 | 10,500 | 18 | " |
| L.Z. 38 | '15 | 8 | | | | | | | | | | | | Army |
| L. 15 | '15 | 5 | 538 | 61 | 1,126,000 | 16 | 16.2 | 4 | 960 | 4 | 62 | 10,500 | 18 | Navy |
| L.Z. 87 | '15 | 4 | | | | | | | | | | | | Army |
| L. 20 | '15 | 5 | 587 | 61 | 1,264,000 | 18 | 17.9 | 4 | 960 | 4 | 62 | 11,500 | 18 | Navy |
| L.Z. 97 | '16 | 7 | | | | | | | | | | | | Army |
| L. 30 | '16 | 14 | 647 | 79 | 1,950,000 | 19 | 32.5 | 6 | 1,440 | 6 | 65 | 12,500 | 22 | Navy |
| L.Z. 113 | '16 | 2 | | | | | | | | | | | | Army |
| L. 42 | '17 | 2 | 647 | 79 | 1,960,000 | 18 | 36.4 | 5 | 1,200 | 5 | 62 | 16,500 | 22 | Navy |
| L. 44 | '17 | 2 | 647 | 79 | 1,970,000 | 18 | 37.8 | 5 | 1,200 | 3 | 65 | 18,000 | 22 | " |
| L. 48 | '17 | 5 | 647 | 79 | 1,977,000 | 18 | 39.0 | 5 | 1,200 | 4 | 66 | 20,000 | 22 | " |
| L. 53 | '17 | 4 | 647 | 79 | 1,977,000 | 14 | 40.0 | 5 | 1,200 | 4 | 67 | 21,000 | 22 | " |
| L. 57 | '17 | 2 | 745 | 79 | 2,418,000 | 16 | 52.1 | 5 | 1,200 | 4 | 63 | 18,000 | 22 | " |
| L. 60 | '17 | 6 | 647 | 79 | 1,977,000 | 14 | 40.0 | 5 | 1,450 | 4 | 71 | 21,000 | 22 | " |
| L. 70 | '18 | 1 | 696 | 79 | 2,196,000 | 15 | 44.5 | 7 | 2,030 | 6 | 77 | 21,000 | 30 | " |
| L. 71 | '18 | 2 | 696 | 79 | 2,196,000 | 15 | 48.0 | 6 | 1,740 | 6 | 75 | 23,000 | 30 | " |
| L. 100 | * | .. | 785 | 97 | 3,812,000 | 14 | 82.0 | 10 | 2,900 | 10 | 82 | 24,500 | 40 | " |
| | | | | | | *(b) Schütte-Lanz Airships* | | | | | | | | |
| S.L. 2 | '14 | 1 | 475 | 59 | 883,000 | 15 | 8.0 | 4 | 720 | 4 | 55 | 8,000 | 14 | Army |
| (Rebuilt, '15) | | | 515 | 59 | 967,000 | 16 | 10.4 | 4 | 840 | 4 | 56 | 8,000 | 14 | " |
| S.L. 3 | '14 | 3 | 504 | 65 | 1,144,000 | 17 | 13.2 | 4 | 840 | 4 | 57 | 8,000 | 14 | |
| S.L. 6 | '15 | 2 | 533 | 65 | 1,235,000 | 18 | 15.8 | 4 | 840 | 4 | 57 | 8,500 | 18 | Navy |
| S.L. 8 | '15 | 2 | 574 | 66 | 1,370,000 | 19 | 19.5 | 4 | 840 | 4 | 57 | 11,500 | 18 | and |
| S.L. 10 | '15 | 9 | 574 | 66 | 1,370,000 | 19 | 21.5 | 4 | 960 | 4 | 60 | 11,500 | 18 | Army |
| S.L. 20 | '16 | 3 | 653 | 75 | 1,977,000 | 20 | 35.3 | 5 | 1,200 | 4 | 62 | 16,500 | 22 | |
| | | | | | | *(c) Parseval Airships* | | | | | | | | |
| P. IV | '13 | 1 | 310 | 51 | 353,000 | .. | 3.4 | 2 | 360 | 2 | 48 | 11,000 | 8 | Army |
| P.L. 19 | '14 | 1 | 303 | 51 | 364,000 | .. | 3.3 | 2 | 360 | 2 | 48 | 10,000 | 8 | Navy |
| P.L. 25 | '15 | 1 | 396 | 54 | 494,000 | .. | 6.0 | 2 | 420 | 2 | 44 | 8,000 | 10 | " |
| P.L. 26 | '16 | 1 | 514 | 62 | 1,059,000 | .. | 14.0 | 4 | 840 | 4 | 50 | 10,000 | 14 | " |
| P.L. 27 | '17 | 1 | 521 | 64 | 1,105,000 | .. | 18.0 | 4 | 960 | 4 | 56 | 14,500 | 14 | " |
| | | | | | | *(d) Gross Airships* | | | | | | | | |
| M. IV | '14 | 1 | 395 | 52 | 688,000 | .. | 7.0 | 3 | 480 | 4 | 52 | 6,500 | 12 | Army |

*Ordered from the Zeppelin Co.; construction not begun owing to the Armistice.

for about ten Zeppelins would be built in the time it took to erect a single shed of large size.

Reasons of space forbid discussing in detail all the improvements which were gradually incorporated into the German rigids and non-rigids. A few remarks, however, seem to the point.

With reference to the Zeppelin airships, the L.3 type represents pre-war design, the first ship of the series being completed just before the war. This type had a long cylindrical hull of poor aerodynamical shape, cellular rudders and elevators of high resistance, and four propellers mounted on outriggers on the sides of the hull which were driven through bevel gear shafts leading to the cars in which the engines were housed.

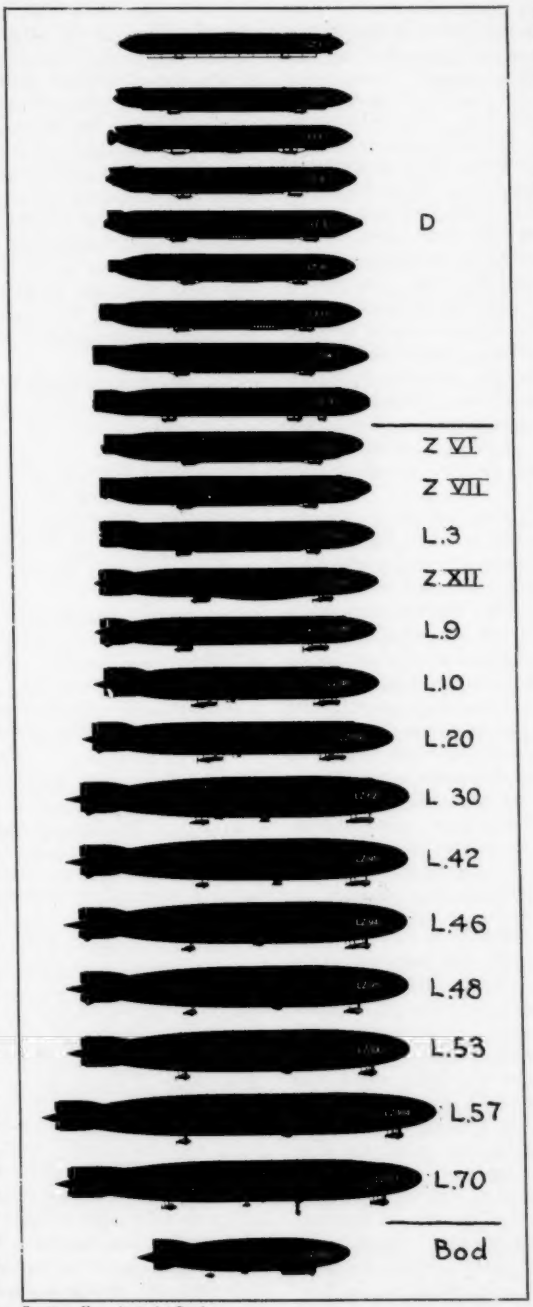
While this type was in production the Zeppelin Co. built the first ship of an experimental type, the Z.XII, in which an effort was made to reduce the large amount of head resistance offered by the cellular control surfaces and the propeller drive. The control and stabilizing surfaces were combined in a cruciform tail and the forward outriggers were suppressed, the forward engine being made to drive, through a gear box and a disc clutch, a single propeller fitted at the end of the car. The performance of this experimental type was so conclusive that when the authorities required the laying down of a type embodying a larger useful load, higher speed and higher ceiling, the Zeppelin engineers decided to adopt the new propeller drive and the cruciform tail for the new ships. At the same time it was realized that the performance could still be improved by giving this type a smaller fineness (length/diameter) ratio and so it came about that the first war production type, the L.10, was only a few feet longer than the preceding type, whereas its diameter was 12 feet larger. The fineness ratio was thus reduced from 10.6 to 8.8 and the performance, owing to the better streamline of the hull, was notably improved. The outrigger propeller drive was retained for the rear car, but this now housed three engines, one of these driving a stern propeller, and another stern propeller was mounted in the forward car. When, in the summer of 1915 the new Maybach 240 hp. engine became available, it was substituted for the old 210 hp. type, resulting in a slight increase in speed of these ships.

Before the close of that year a new problem came up, however. The greatly improved climbing ability of the Allied airplanes and the greater accuracy of anti-aircraft guns now made it imperative for the German airships not only to climb higher than heretofore, but also to climb faster. The naval and military authorities of Germany therefore demanded a greater margin of useful load to allow for carrying extra ballast. The Zeppelin engineers temporarily solved the problem by adding a gas cell to the L.10 type, whereby the useful load was increased by about a ton and a half. The resulting L.20 type was, however, soon to be replaced by a vastly improved vessel and when this made successful trials, the production program of the L.20 type was stopped with the sixth

vessel of the series, which was then in process of construction.

The new airship, the L.30, was the first of the so-called "super-Zeppelins"—as we referred to them during the war. In the design of this type the Zeppelin engineers once more used the familiar procedure of increasing the diameter at a greater rate than the overall length, and by so doing they reduced the fineness ratio to 8.2, producing a ship of notably clean lines. The most remarkable innovation found on the L.30 type is, aside from its huge size, the propeller drive. The power plant consisted of six 240 hp. Maybach engines which drove six propellers disposed as follows: Two astern of the main cars, two on outriggers aft, and two amidships on small "wing cars," fitted on either side of the hull, which served as engine rooms only. Owing to the head resistance of the outriggers and the interference of several propellers with one another, the performance of this heavily engined airship did not entirely come up to expectations, and steps were accordingly taken to "clean up" the design.

First the number of engines was reduced to five, the stern propeller of the after car being dispensed with together with its engine. Then, on another type, the outriggers were also suppressed so that the number of propellers was reduced to three, that is, one astern of the forward car and two on wing cars. The latter were however fitted with two engines each, either or both of which could drive the propeller through a suitable gear box and clutch arrangement. This scheme, which was intended to provide for emergencies, proved so satisfactory that the principle was incorporated in the final design of the modified L.30 (or L.48) type. In the latter there were four propellers disposed in a quadrilateral, two being in the center line and two in wing cars, and the rear main car housed two engines, one to be used for emergencies. The saving in head resistance which the suppression of the outrigger propellers represented enabled these ships to have a much better performance than the L.30 type, although their power plant was smaller. The great reluctance the Zeppelin engineers displayed in parting with the outrigger drive may be understood when it is known that this system was their own invention, whereas the wing cars had been originated by the rival Schütte-Lanz firm, which has used this drive on all of its ships ever since 1914.




Courtesy, U. S. Army Air Service

SILHOUETTES OF DIFFERENT TYPES OF ZEPPELIN AIRSHIPS FROM 1900 TO 1919

The next step in improving the L.30 class consisted in generally lightening the construction. Thus the stern was deprived of its gas bag, it being deemed that the lift derived from it was out of proportion to its weight. Then, in the summer of 1917, came a much more radical innovation. The L.48 type, or L.30 type with the standard propeller drive, was entirely redesigned in detail, as a result of which the length of the gas cells was increased from 33 feet to 49 feet and their number was reduced from 18 to 14. The saving in dead weight amounted to a ton and the ceiling of the ships was improved in proportion, while maneuvering became more convenient owing to the lesser number of gas bag controls. Against this advantage was the drawback that the hull, having now two intermediate transverse girders between the main, stress-taking, frames, proved less resistant than the old design and required frequent overhauling. The introduction of a new high resistance aluminum alloy only partly solved this problem.

Another danger against which the Zeppelin engineers had to provide in this L.53 type was the surging of the gas against the high side of the ship or against the wire wall of a gas cell that might accidentally become deflated. To provide against this contingency, which might have serious consequences owing to the large amount of gas contained in each bag—about 200,000 cubic feet in those located in the parallel portion of the hull—each gas bag was not only securely fastened to the framework by wires, but it was also internally trussed by radial wires.

Having reduced the number of gas cells in the improved L.30 type, the Zeppelin engineers were once more at liberty to increase its size for special requirements by the addition of further gas cells. Thus in the L.57 type, which was produced for special long range scouting, the capacity was increased to 2,400,000 cubic feet and the useful load to over 52 tons, with a corresponding decrease in speed and ceiling. Only two ships of this type were built, one of which made a 4,500-mile flight from Yamboli, Bulgaria, to the Soudan and return in an attempt to deliver 12 tons of medical supplies to the German forces in East Africa. Before the airship could reach its destination, however, it was recalled by a radio, the German forces in question having surrendered in the meantime. This flight is the longest non-stop voyage made by an airship to date.

In the winter of 1918 it became increasingly evident that unless the German airships could show a much better speed and climb they would, one after the other, be brought down by Allied airplanes and anti-aircraft guns. In an endeavor to solve this problem the Zeppelin engineers first fitted the L.53 type with the 290 hp., or super-compressed, Maybach type engine, and later produced the L.70 type, which was the most

heavily engined airship ever built. It had seven 290 hp. engines, four of which were mounted in wing cars, and developed a speed of over 77 m.p.h., but its ceiling was already inadequate, for British aviators brought the ship down in flames in the North Sea on one of its early raids. The sister-ships were thereupon modified by removing the reserve engine from the rear car, which increased their ceiling by 2,000 feet, and plans were laid down for the construction of a much larger series, the features of which appear in Table I. The latter, L.100 type, was ordered before the armistice, but construction had not begun when hostilities ceased.

### THE SCHÜTTE-LANZ AIRSHIPS

The Schütte-Lanz airships were originally built of laminated wood girders trussed with wire stays. In appearance they were dissimilar to the Zeppelin ships in that they had streamline hulls long before the Zeppelins had them, just as they used the quadrilateral propeller drive in advance of their rivals, and originated the internal passage way. As the war progressed, however, there came a visible merging of the two designs, until finally the Schütte-Lanz Company even gave up the most distinctive feature of its design, the wooden framework. This had first been chosen because in theory it worked out at a lesser weight than the duralumin construction and because it was more easily constructed and repaired. The wooden framework would also have an amount of springiness to take up shocks with little injury such as would gravely damage a Zeppelin.

Practical experience did not fully bear out these assumptions. It is true that after several years of effort the Schütte-Lanz ships carried for the same capacity a larger useful load than the Zeppelins and that their ability to stand punishment was also greater. On the other hand the wooden framework had the serious drawback of getting out of alinement under the influence of the weather and its assembling required much more time and painstaking work than that of a Zeppelin. The want of weather-proofness of the S.L. ships explains why the German navy always looked askance at this type of construction and the manufacturers finally admitted this drawback themselves, for the S.L. 20, the last of their war series, had a framework of duralumin tubes instead of being built up of laminated wood. The experience of this firm in metal construction was too recent, however, to enable them to compete on even terms with the Zeppelin Company, which accounts for the superior performance of the latter's ships.

### GERMAN NON-RIGID AIRSHIPS

Of Germany's non-rigid airships only the Parseval types deserve special mention. Although only a limited number were built owing to the acute rubber shortage Germany experienced, the later Parseval ships were remarkable for the large useful load they carried. They greatly exceeded in this respect their rigid contemporaries of the same size, but their speed was inferior. The most serious objection that came up against their use in warfare was the difficulty of keeping the envelope taut and so maintaining the shape of the hull when the ship was under way at high speed. This experience bears out the pre-war assumption that there is a limiting size beyond which it is not practical to build airships that depend on internal pressure for keeping their form, because the high internal pressure required demands a very heavy fabric—which detracts from the useful load—and also because such ships are particularly liable to mishaps owing to failing pressure.

It is interesting to note in passing that the last two Parseval airships built during the war differed from the well-known pre-war types in that a long metal girder was slung under the envelope in order better to distribute the disposable loads, such as gasoline, ballast, etc. Two wing cars were stayed to this girder amidships, while two more engine cars and a control car, forward, were suspended from it in the centerline. These large Parseval ships have thus, like the Schütte-Lanz vessels, five separate cars, which system has the advantage of removing all noise and vibration from the control car, where the radio cabin was located.

A point particularly worth mentioning is that toward the end of the war the Parseval Company started experimenting with various aluminum alloys with a view to determining whether medium size airships could not be built more economically on the rigid principle than on the pressure system. These experiments dealt in particular with duralumin tubing, which, it is said, the company intends to use in the framework of an experimental airship.

The Gross airship, M.IV, listed in Table I, was a pre-war product, having been built by the now dissolved Balloon Battalion of the Prussian army. The ship is not particularly notable, except perhaps for the fact that it affords the only record of German experiments with mooring airships to a mast, and that it belonged to the original German semi-rigid type. This was characterized by an underslung metal girder, from which two cars were suspended, a scheme which—as we have said above—was later incorporated with several improvements in the later Parseval airships. For this reason the latter were strictly speaking semi-rigid ships and not non-rigids, as the Germans called them.

TABLE II—GERMAN AIRSHIP LOSSES—1914-1918

| Type of airship | | Z. | S.L. | P. | M. | TOTAL | |
|---|---|---|---|---|---|---|---|
| Brought down in action | A | 5 | 1 | .. | .. | 6 | 27 |
| | N | 20 | .. | 1 | .. | 21 | |
| Damaged in action, wrecked on landing or foundered | A | 9 | .. | .. | .. | 9 | 15 |
| | N | 6 | .. | .. | .. | 6 | |
| Wrecked in sheds by airplane bombs | A | 2 | .. | .. | .. | 2 | 4 |
| | N | 2 | .. | .. | .. | 2 | |
| Lost in bad weather | A | 4 | 3 | .. | .. | 7 | 17 |
| | N | 6 | 4 | .. | .. | 10 | |
| Accidentally lost through fire | A | .. | 1 | .. | .. | 1 | 15 |
| | N | 10 | 3 | 1 | .. | 14 | |
| Scrapped | A | 13 | 6 | 1 | .. | 20 | 31 |
| | N | 6* | 2 | 2 | 1** | 11 | |
| Wilfully wrecked after the Armistice | A | .. | .. | .. | .. | .. | 7 |
| | N | 7 | .. | .. | .. | 7 | |
| Surrendered to the Allies | A | .. | .. | .. | .. | .. | 7 |
| | N | 7*** | .. | .. | .. | 7 | |
| Total | | 97 | 20 | 5 | 1 | 123 | |

*Including two ex-army ships transferred to the navy.

**Ex-army ship transferred to the navy.

***Including two ex-army ships transferred to the navy, and the L.72, completed after the armistice. One of these ships, the L.37, is yet to be delivered, disassembled, to Japan.

Table II indicates Germany's airship losses during and as a result of the war. The letter Z stands for Zeppelin, S. L. for Schütte-Lanz, P. for Parseval and M. for Gross, while the letters A. and N. stand for army and navy, respectively. In the number of Zeppelin ships given there are included three former passenger airships of the Delag Line which the army authorities requisitioned on the outbreak of the war.

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## LIGHTING INSTALLATION FOR NIGHT FLYING

IN cases where it is necessary to indicate air routes by night, comparatively weak sources of light are adequate, and electric or gas lamps sending out intermittent beams according to some prearranged signal are suitable. The optical system should be such that the strongest rays are emitted horizontally with a gradual diminution in intensity toward the zenith.

In order to lessen the danger due to forced landings at night, it is suggested that airplanes should have a number of electric lamps attached to their main planes, so arranged as to illuminate the landing place. As the lamps would only be used at intervals and then only for short periods they might be overrun so as to give a strong light. The author suggests eight lamps to give 26,000 candle-power each.—Abstracted by *The Technical Review* from *Illustrierte Flug-Welt*, Dec. 22, 1920.

# Petroleum as a Source of Soap*

## Converting Non-Saponifiable Bodies into Acid Products and Then Combining with Alkali

FATTY bodies, using the word in the ordinary sense, can be divided into two groups: Those which are saponifiable and those which are non-saponifiable. The former include the oils and fats extracted from land animals and marine animals, and the vegetable oils: including those which are siccative, semi-siccative and non-siccative oils, and solid fats. To the second class belong the mineral oils, oil of turpentine, oils of tar and pitch and the essential oils.

The saponifiable fats include *one or more of the following fatty acids*: Butyric acid (butter), caproic acid (butter from the goat and the cow and cocoa butter), caprylic, palmitic, stearic, oleic, linoleic, and linolenic, combined with glycerine in the form of readily saponificable ethers.

A great many of these natural ethers of vegetable or animal origin are used in the form of food; others are employed for making soaps; and still others are utilized as lubricants or for fuel.

During the war fatty substances of all sorts were very scarce everywhere and particularly so in Germany; it was necessary to keep the larger part of the supply for food purposes, consequently the amounts usually supplied for fuel and lubrication were cut down and the soap boilers' supplies were greatly reduced. These circumstances caused much ingenuity to be expended in the effort to obtain improved methods for transforming into saponifiable fats those fatty bodies obtained from petroleum which it is impossible to transform directly into soap.

All the fatty bodies which contain fatty acids combined with glycerine in the form of ether are capable of yielding soap when treated with an alkali; in order to obtain soap from materials which are naturally non-saponifiable it is necessary to transform these neutral substances *into acid products which can be later made to combine with alkali*. All processes thus far devised have this purpose in view.

The four principal methods of attaining this object are thus stated by Moore and Egloff:

1. The halogenation of the aliphatic carbides;
2. The employment of organo-magnesian compounds (Grignard's reaction);
3. The use of naphthenic acids;
4. The direct oxidation of paraffins and olefins.

### I. HALOGENATION OF ALIPHATIC CARBIDES

The aliphatic carbides are the *essential constituent portions of American petroleum*, which contain all the terms from the terms having six atoms of carbon to those containing 60 atoms. The boiling point increases in proportion to the number of carbon atoms.

It is those carbons which boil at about 300° cent. which are most frequently used, *i.e.*, those which approximate the terms $CH_3 - (CH_2)_{14} - CH_3$. If this latter group $CH_3$ could be transformed into the acid radical COOH we should have palmitic acid which is very abundant in all fats and oils. This first stage of the reaction can be accomplished by the action of chlorine upon the carbide.

Hence the substitution in a methyl group of a carboxyl group yields, therefore, for the hexadecane $CH_3 (CH_2)_{14}CH_3$ palmitic acid $C_{15}H_{31}COOH$.

Chlorine may be introduced in various manners. In the process, for example, employed in the *Badische anilin u. soda Fabrik* the halogen derivatives of the paraffinic series of hydrocarbon are produced by mixing the oil and the halogen in the dark and then vaporizing the mixture by subjecting it to a silent electric charge. Others utilize the action of the ultra-violet rays. Moore and Egloff cause a mixture of chlorine and carbide vapors to which they have added a certain percentage of carbon anhydride to pass through a silent electric discharge while hot. After condensation the density of the carbide is greater and when it is treated with caustic soda it forms an emulsion, showing that there has been a formation of fatty acids.

The transformation of the halogen derivative into the fatty acid can be made by direct oxidation of the derivative or by passing through the intermediate stage of alcohol.

### II. GRIGNARD'S REACTION

The Zelinski process, which is said to be capable of giving a 60 per cent yield, dates from before the war. Even then it was an accepted fact that by means of this process it was possible to produce fatty acids industrially starting from hydrocarbons, but the cost was too high for it to be undertaken.

According to this process the hydrocarbon is first treated with chlorine after which the product is dissolved in anhydrous ether and acted on by metallic magnesium in the presence of a catalyzer; a magnesium compound is formed which is treated with a current of carbonic anhydride; in this manner an addition compound is obtained which upon being decomposed by water yields an acid and an oxy-chloride of magnesium. The method is costly because of the high price of such reagents as magnesium and anhydrous ether.

### III. USE OF NAPHTHENIC ACIDS

Naphthenes are carbides saturated with hydrogen like the hydrocarbons of which we have just been speaking. They form the larger part of the petroleums from Baku and Galicia in which there are also found small amounts of their oxidation products, the naphthenic acids—namely, 0.9 per cent. When petroleums are washed with alkaline lessives these acids are found in the wash water.

We owe to Pyhalla the suggestion made in 1914, that these might be transformed into soap. When they are changed into ethers of glycerine we obtain products very different from the natural substances. They form plastic masses from which artificial rubbers may be made.

### IV. DIRECT OXIDATION OF PARAFFINS AND OLEFINS

This is the most direct method of synthesis and the one of most interest from a commercial point of view.

*The Benedix Process.*—This consists in making by means of stirring or shaking an intimate mixture of vaseline or oil of vaseline with hydrogen peroxide or alkaline water with peroxide of sodium. Oxidation slowly takes place and a fatty acid is obtained which forms a soap with the alkali employed. The operation is facilitated by adding alcohol and by heating under pressure to 80° cent.

A small amount of fatty acid was likewise obtained by Schultz by passing a rapid current of air over boiling paraffin.

According to Schmidt and Hulsberg the melted paraffin is treated for a long time by a current of air or oxygen at a temperature of 100 to 120° cent. Little by little the color acquires a reddish tint which passes into pale yellow and finally into deep yellow. In this manner it is possible to obtain fatty acids in the proportion of 70 per cent of the paraffin employed. They are accompanied by a small amount of alcohol and of formaldehyde and its homologues which are separated out by fractional distillation. The yield can be increased by the use of catalyzers such as oxide of mercury for example. By this method it appears possible to transform from 80 to 90 per cent of the paraffin into fatty acids. A very good yield can likewise be obtained by treating the paraffin with air under pres-

*Translated for the *Scientific American Monthly* from *La Nature* (Paris) for Feb. 19, 1921.

sure at a temperature of 90 to 175° cent. under the influence of ultra-violet rays and in the presence of catalyzers such as metals in a very fine state of division.

*Olefins.*—However, it appears to be better to make use of olefins which are non-saturated compounds that are readily oxidized instead of employing such very stable saturated compounds as the paraffins. These olefins are not very plentiful in nature, but on the other hand it is very easy to obtain them from petroleum merely by subjecting them to the process known as "cracking" (pyrogenous distillation). The following decompositions are produced in succession:

$$\text{Paraffin } C_{20}H_{42} \begin{cases} \text{olefin } C_{10}H_{20} \\ \text{paraffin } C_{10}H_{22} \end{cases} \begin{cases} \text{olefin } C_5H_{10} \\ \text{paraffin } C_5H_{12} \end{cases} \begin{cases} \text{olefin } C_4H_8 \\ \text{paraffin } CH_4 \end{cases}$$

When the heating is prolonged we obtain only the gaseous and liquid products of the ethylenic and acetylenic series and the higher the cracking temperature becomes the higher is the degree of non-saturation.

*Green Street Process.*—In this method the mineral oils are borne by water vapor across long tubes heated to a cherry red. In this manner there are formed olefins which are oxidized and the different products are separated by distillation. The oxidation is obtained by treating first with sulphuric acid and then by the action of water upon the sulphurated derivatives. They can also be oxidized by means of permanganate of ozone or of the chromic mixture. The treatment by ozone yields ozonides which can be decomposed by water vapor to produce fatty acids. The latter can be transformed into soaps by means of alkalis or into glyceric ethers by heating with glycerine under pressure to 200° cent. in the presence of Twitchel's reagent (a sulphoaromatic compound), or under the influence of enzymes. The fatty acids obtained by synthesis can thus be transformed into higher acids by hydrogenation:

$$\underset{\text{Linoleic acid}}{C_{17}H_{31}COOH} + 2H = \underset{\text{Oleic acid}}{C_{17}H_{33}COOH} + 2H = \underset{\text{Stearic acid}}{C_{17}H_{35}COOH}$$

*The Hydrogenation of Oils.*—This process has been increasingly employed of recent years; it increases as we shall see the yield of concrete acids. It is in some sort a partial synthesis whose practical results are quite considerable, since it makes it possible to transform oils of an inferior commercial value into products of much more worth.

The liquid fatty substances composed of non-saturated fatty acids, namely, olein, linolein, and linolenine do not differ from the solid fats composed of stearic acid except by one or more molecules of hydrogen at least, and it is by means of a catalytic process that it has been found possible to fix the hydrogen upon the fatty acids by augmenting their fusion point and by approaching more or less closely their saturation point. Professor Sabatier of Toulouse was the first person to succeed in transmitting hydrogen to non-saturated bodies under the catalytic influence of finely divided metallic nickel. He secured this synthesis by causing a mixture of hydrogen and the vapor of the product to be treated to pass over finely divided nickel heated in a tube. But such a process can have no commercial value since most of the fatty bodies are not capable of being volatilized and decomposed at a high temperature.

The first practical achievement along this line was accomplished by Normann, who passed hydrogen into heated oil containing the catalyzer held in a suspended state by means of vigorous mechanical agitation.

The nickel forms with the oil a colloidal solution which makes it possible for the hydrogen to be absorbed and fixed in spite of its rapid passage through the mixture.

The best catalyzers for this purpose are finely divided metallic nickel, nickel oxide, and palladium. Nickel oxide is the one most often used; it is both easier to get and less fragile than pure metallic nickel itself.

Furthermore, the consumption of hydrogen is the same whatever the catalyzer employed: *i.e.*, about 100 cubic meters per ton of oil transformed into solid fat. The same amount of oil requires only 5 to 6 kg. of the nickel oxide catalyzer, whereas nearly 20 kg. of metallic nickel would be needed to produce the same result. The *industrial apparatus most commonly used* is that devised by *Wilbuschevitsch*, which consists of an autoclave in which the catalyzer is emulsified with the oil; the emulsion is reduced to a fine spray by means of a jet of hydrogen, a suitable pressure and temperature being maintained.

Five autoclaves of the same type are usually placed so as to form a series and the oil is made to circulate in such a manner that its fusion point rises 15° cent. in each container. The temperature is held at 150° cent. and the pressure at 9 kg. The catalyzer can be recovered by centrifugation or by passing the hot fat through a filter press.

The nickel oxide catalyzer is prepared as follows: A solution of pure nickel nitrate is made at 15° Baumé and washed by acids and by pure water and then dried, after which it is impregnated with some inert, porous, finely powdered substance such as Rieselgnhi. It is then treated with a solution of carbonate of soda so that carbonate of nickel is obtained; the latter is calcined to decompose it into the oxide. To obtain the metallic nickel catalyzer it is only necessary to reduce this oxide by means of a current of hydrogen at about 350° cent. and before cooling to enclose it in grease to preserve it from the action of the air.

The hydrogenation of oils is more and more made use of in industry, and there are hopeful prospects that this process, combined with that of the synthetic production of fatty acids, will make up for the scarcity of the raw materials required in soap boiling, and the stearine industry.

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## IS IT POSSIBLE TO OBTAIN IMAGES OF MOLECULES?

THE interesting question has been raised among scientists as to whether any method can be devised capable of producing optical images of molecules, such for example as the molecular space lattices which compose crystals according to the modern view. This question at first thought so startling is answered in the affirmative by a Swiss man of science, M. Wolfke, of Zurich, who recently read an article upon this subject before the Swiss Society of Physics. As reported in the *Archives d.Sciences phys. et Nat.* (Switzerland) for May, June, 1920, Mr. Wolfke basis his belief upon his previous researches concerning the theory of optical images, which were set forth in the *Annals der Physik* (Berlin) in 1912 (Vol. XXXIX).

His method consists in substituting for the intermediate image (primary) a photograph obtained by means of X-rays. This substitution is based upon a new theory, a demonstration of whose correctness is furnished by the author as follows:

"The diffraction image (primary) of a diffraction image (primary) of any object whatever, both of which have been obtained by means of parallel monochromatic light is identical with the image proper (secondary) of this object, provided that it have a symmetrical structure without marked differences of phase." This result has been verified by means of experiment with a number of different optical space lattices.

By this method the coördinates of the object appear to be enlarged in the ratio $\lambda/\lambda'$ of the lengths of wave employed for the production of the new and of the first images of diffraction. By making use of X-rays to produce the first diffraction image of the object, an ordinary visible light to produce the second (the image proper of the object), it is possible to obtain in this way an enlargement of the object of the magnitude of 10,000. By the help of suitable optical systems the degree of magnitude of this enlargement of the image can be raised to several millions and this would enable us theoretically to perceive the molecules which compose the space lattices of crystals. In order to render these visible by means of this process, it is necessary always to employ the diffraction images of a single crystalline plane obtained by means of X-rays.

# Science and National Progress

**Edited by a Committee of the National Research Council**

**Dr. Vernon Kellogg, Chairman, Dr. R. M. Yerkes, H. E. Howe**

## SCIENTIFIC WORK IN RUSSIA OUTSIDE OF PETROGRAD AND MOSCOW*

By Sergius Oldenburg

Permanent Secretary of the Russian Academy of Sciences Since 1904

*The National Research Council is a co-operative organization of the scientific men of America. It is established under the auspices of the National Academy of Sciences and its membership is largely composed of appointed representatives of the major scientific and technical societies of the country. Its purposes are the promotion of scientific research and of the application and dissemination of scientific knowledge for the benefit of the national strength and well-being.*

Petrograd and Moscow are still, as in previous times, the main and basic centers of scientific work in Russia. This is quite natural since within these cities there are concentrated the principal scientific institutions of the country, higher schools and large libraries. Also the greater number of scientific workers is being trained there. However, the conditions of the present moment could not fail to have an effect on the work "in the province," as we are accustomed to say it. First of all, considerable portions of Russia were for a long time torn away from these centers by the civil war. The derangement of the transport also in a considerable measure contributed to the isolation of local centers from Petrograd and Moscow. They were forced to go ahead independently. It then appeared, as might have been expected, that many localities and cities possessed unusual vitality; they revealed great intensity in work, relying on themselves only and not looking for assistance from the outside. This was the case in some places with the older universities and higher schools, while in other parts of the country the work was carried on by former scientific societies; in still other places there formed new institutions of learning and scientific organizations.

Observing closely the life "in the provinces of contemporaneous" Russia one may note a definite tendency toward the study of regional divisions in all their relations. Consequently, there is also a tendency to create new universities, but without an adequate consideration of the local supply of instructors or that of more distant centers from which they occasionally might be obtained. No doubt, many of the regional universities are not destined to live long; even under more normal conditions the teaching personnel in the higher schools is greatly insufficient in numbers, and now, after numerous deaths and emigrations, the available teaching force is, of course, still smaller. The new universities have to reckon with an overwhelming number of vacancies or else accept a personnel not sufficiently qualified for these positions. Life, however, brings certain compensations. Some of these universities will be closed; others will be replaced by less pretentious institutions, and a certain number of them, no doubt, will maintain their rank as universities.

A great deal of vitality has been manifested by a new type of educational establishments—the Institutes of Public Instruction. These resemble somewhat the former Teachers' Institutes, but they are functioning on a more comprehensive and better basis. Among these institutes the one in Viatka met with unusual success. The Viatka region even in former times was from a cultural point of view an oasis: excellent new growth has been obtained on this old good soil. The Viatka Institute of Public Instruction began the investigation of its region with great earnestness, and its teachers have succeeded in drawing the younger generation into this work. Separate circulars dealing with the collection of data on various questions have been issued. Mention may be made of the outlines prepared by Prof. M. M. Karinski for a study of local dialects and of folklore. A small library, a memorial to Hertzen, and a local museum are aiding in this work. No doubt the Institutes of Public Instruction will prove to be a powerful factor in the cultural development of Russia, and will become that type of educational institutions now especially needed in Russia which will prepare the local workers in the varied domains of science.

The universities of Ukraine suffered most of all. They lived through numerous governmental changes and through a catastrophic reduction of teaching personnel. Years will pass, probably, before they again will be raised to a high level. A great deal was suffered also by the University of Peru. Its future is very unsettled in view of the establishment of another rural university which conforms to the new and broader principles of uniting university and polytechnicum and is more or less of the type outlined in 1917. The Ural University, just founded in Ekaterinburg, comprises a series of scientific departments. It is the second higher institution of learning in Ekaterinburg, the first being the Mining Institute. Thanks to the existence of the latter the teaching personnel for a whole series of courses is assured and also some of the necessary laboratories and equipment.

The young universities suffer most from the book famine. The University of Ekaterinburg has among its founders several very energetic men and it undoubtedly belongs to the group of live universities.

The program of 1917 had in view the establishment of three new universities: one in Caucasus, one in Turkestan and one in eastern Siberia. It was fulfilled only as regards Turkestan with a university in Tashkent and in Siberia, with a university in Irkutsk.

The young universities have succeeded in drawing a large number of students and, in spite of all the difficulties, particularly the lack of books and of scientific equipment, continue to perform their scientific work. In part, as for instance in Tashkent, this is done through invitation of specialists from the capitals. Thus, last fall Academician V. V. Barthold gave a course on the history of Central Asia which attracted not less than 500 men. The study of the Orient is being carried on at this university and at the special institute for modern oriental languages. The work is directed by M. S. Andreyev, an eminent authority on the Orient. Attention is given also to the preservation of relics of local antiquity. This is done in close coöperation with the well-known investigator and authority on Turkestan, V. L. Viatkin.

Siberia has lived through a grave civil war and in many respects life there has not yet become normal. Nevertheless, the young Irkutsk University as well as the relatively older Tomsk University are both active. The latter has already organized a series of scientific expeditions dealing with natural history and with ethnographical-archeological studies which have yielded rich scientific results.

The Geological Committee of Siberia which became a branch of the Central Geological Committee, conducted its field work all these years, even during the civil war, in spite of dangers. It may justly be proud of its remarkable achievements. The noted geologist, Y. S. Edelstein, who has just returned to

*Translated from the Russian by Michael Shapovalov.

Petrograd from Siberia, will have a detailed report in the Petrograd journal, *Science and Its Workers* on this scientific work in Siberia. An interesting investigation had been carried on also by the "Institute for the Study of Siberia," but for some unknown reasons this institution has now been closed, much to our regret.

In the Volga region the University of Saratov is especially active, the number of its students this year reaching about 5,000. Aside from its principal object the university also pursues a study of the region in all its aspects. The university youth has been drawn extensively into this work and it organizes numerous excursions either independently or under the leadership of its professors. This work also aids the growth of a good local museum. It should be noted in this connection that the museum work meets not only with a general sympathetic response in the country, but also with the support of rather wide masses of people. The objective expression of all peculiarities of a local region in a museum collection attracts every more or less "live" person and thus leads to the further accumulation of material which is not only valuable for educational purposes, but also for purely scientific interests. It is well known how much has been accomplished in this way in Finland and in the Scandinavian countries. There is one more very important phase to this affair: the creation of local specialists in one or the other sphere who can on the spot collect material or make observations throughout decades with remarkable keenness. Such persons are exceptionally valuable for the region itself and also for science. We may recall, for example, Martyanov, who was able to build up an archeological museum of world importance in the Minussin wilderness; or Pastor Billenstein who through decades of labor produced a classical contribution on wooden structures and utensils of the Letts published by the Academy of Sciences; or Pastor Hoort who collected a surprising quantity of relics illustrating the creative activity of the people; or Rudchenko who gathered material for a large volume of Ukranian fairy tales. There are many more such modest yet remarkable investigators and collectors in various places. New universities and Institutes of Public Instruction have already given their attention to them.

Very actively at work is the Northern region—the Yaroslav province and parts of the Tver and Vologda provinces with their periodical congresses. Local workers seek to harmonize their activities with the work of the central institutions and for this reason they particularly feel the effect of the typographic derangement which prevents the establishment of regular communication by means of special publications. It is, therefore, especially gratifying to note such rare exceptions as the large series of works of the Kuban Soviet on Regional Investigations with an extensive regional bibliography; the contributions from the local Kostroma society and the publications of the Museum Division in Kazan on museum matters. Irregularities in mail communications, unfortunately, prevent the systematic delivery of these contributions to the centers and in general to localities outside of the places of issue.

In the absence of an adequate system of book registry general information is lacking as to many of these publications. It is only through personal communication that one succeeds in learning more or less satisfactorily concerning the little which is being published. We have not learned as yet the vital importance of "reference books" which are maintained so admirably in the West and which are the most essential element in every organized and systematic work.

In this brief review I wished to indicate a few things which are being done for science in Russia outside of its large centers, Petrograd and Moscow. Being a convinced optimist and having a profound faith in Russia, I certainly do not close my eyes to whatever is inefficient and wrong in our present scientific work; more than once I have pointed out how scientific workers are enchained by the almost absolute impossibility to publish and how this curbs every effort. There are many other conditions interfering with the work, and yet this work is not only carried on, but we can see how new fields are being mapped out and how new intellectual forces are being awakened to activity. It also appears now as though the masses were beginning to realize that scientific work signifies more than merely idle pleasure or caprice. They appear to understand that an extensive development of science and scientific knowledge and of creative thought is the basis of the brighter future of humanity. The local scientific work has this great significance that it is being performed in the eyes of the whole population and that it affects them directly. Only when broad masses actually will have faith in science, may we be confident that no turbulence will endanger scientific work; it will then be guarded by all as the great and the most valued possession of all humanity. We hail, therefore, particularly our local workers who pursue so firmly their work—work so modest in appearance, but in reality of unusual importance; they are pursuing it in all the corners of our great country, untiringly, without folding their arms.

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## SCIENCE FOR THE MILLIONS

IT is sixty years since since Herbert Spencer's discussion of the question "What Education Is of Most Worth?" set English speaking people to thinking as they had not thought before about the value of science and its claims to a place in popular education.

Today the problem of science in education has passed beyond the stage of debate on the general educational value of this domain of knowledge and deals with such questions as that of finding a place for science in the common school curriculum; of what particular sciences shall be taught according to circumstances; how they shall be taught, and so on.

Perhaps the master problem of all now is, How shall the great rank and file of the population be assured that minimum of natural knowledge without which prosperity and progress and happiness in the modern world are impossible?

An effort to do something toward solving this great problem has culminated in the establishment at Washington of an institution to be called "Science Service," the history of which is sketched here for the first time.

"If we must have democracy we must have a more intelligent demos." These words were spoken just as the Great War was ending in such ruin of monarchic and autocratic government and triumph of sentiment and theory at least, of popular government as had never before been seen. They were spoken by Mr. E. W. Scripps whose whole life has been devoted to building up newspaper organizations, the published matter of which reaches millions, and the labor on which is performed by thousands of the demos. The utterance delivered from such an experience had in it somewhat of misgiving about democracy. For better or for worse, democracy is inevitable. This being so, the part of wisdom is to make sure that it shall be for better and not for worse.

Now toward one conclusion experience of all peoples and all ages points unerringly: Without a highly intelligent demos, a highly good democracy is out of the question. But for this age, and this stage of world progress such a conclusion is too general. The vastness and complexity of conditions under which modern men and nations exist are such as to demand intelligence in many different fields.

The demand is not for theoretic completeness as to what intelligence ought to cover but for active effort in behalf of intelligence concerning those things and forces which are most distinctive of the times—those things which pervade it most; which are most potent in it. And what are those things? No broadly seeing, carefully thinking person who is likewise a participant in the real life of the age, can hesitate over an answer: The things and forces which are the subject matter of physical science are the ones that dominate, and overwhelmingly dominate, our era. That this is the "age of science" is acknowledged by everybody, even by many who deprecate the fact.

So the practical but likewise philosophical man whose words form our opening sentence, having reached the conviction expressed by that sentence, hesitated not at all as to the general province in which effort should be made to increase the intelligence of the demos. It should be in science. But it should be science in no paltry sense. It should not be science reduced, as in many minds it is today, to the narrow, unhumane bounds of industrial technology. It should be science more in the traditional sense—in the sense of indisputable objective knowledge of whatever kind or source.

But what agency should be used in this effort? Here is another saying of Mr. Scripps: "Whether for good or for bad; whether we like it or whether we don't, ours is an age in which 'public opinion,' control by which reaches to political government, is made by newspapers—by the daily press—more than by any other influence whatever."

The public school? Undoubtedly a mighty factor for enlightening the masses in science as in all else. But the school touches directly and potently only children and youth. *The great life-continuation school is the Press;* and so rapidly and revolutionary does new knowledge come into the modern world and new forces play upon it, that education of youth in the elements and historic deposits of learning cannot at all answer the needs of modern peoples. Life-continuation education is vital.

With such convictions; with such a business experience; and with such a structural foundation to build on, what more natural than that a project for *increasing the intelligence of demos in science by means of the journalistic press*, should be conceived?

So much for the germinal idea of Science Service. A little now concerning its coming into existence and its organization.

The very essence of adult human living and of adult intelligence forbid that any major agency for life-continuation education should be philanthropic. Serious adult education must be an essential part of real life. It cannot be a charity. It must be a part of the whole business of life and so must be on a business basis. It must pay its own way. Like any other business it must have some capital and must earn money as well as spend money; indeed, it must, finally, earn at least as much as it spends in order to be a "going concern."

But with such an aim as the contemplated educational enterprise would have, earnings for profit in the business sense would be wholly incompatible. No individual should get money from it on any basis other than that of pay for service rendered. But just as the service rendered by the enterprise to individuals or public should not be as charity, so no regular service of individuals to the enterprise should be as charity.

*Self-supported public service* should be the business motto of the undertaking.

With such conceptions Mr. Scripps has furnished the new enterprise a substantial initial or working capital.

Another principle laid down by the initiator of the enterprise was that because science was to be its field, professional scientists ought to be chiefly, if not wholly responsible for its creation and operation. Only through the efforts of scientific men themselves, said Mr. Scripps, would there be the least chance of success for such an experiment. Not merely their endorsement of it and sympathy for it, but their willingness to work for it, would be indispensable.

"I can do no more," he said, "than say to the scientists of the country, 'Here is the germ of an experiment in disseminating science among the people, and some money for carrying out the experiment. But the experiment itself if tried at all must necessarily be tried by you.'"

The accident, perhaps, of proximity, brought the idea thus outlined to the attention of the writer in the summer of 1919.

The matter seemed to him to contain such possibilities of good that he volunteered to bring it to the attention of the scientific men of the country as far as this could be done within the bounds of reasonable expenditure of time and effort. With this view he devoted two months during the winter of 1919-1920 to visiting a considerable number of the chief centers of scientific research of the country and holding personal and group interviews on the subject with workers in science. A total of nearly three hundred men were reached, and, to a large extent, their views obtained.

On the basis of this study it seemed justifiable to conclude that full fifty per cent of the scientific men of the United States were unqualifiedly favorable to such an experiment and were willing to help it on in such ways as they could; that some forty-five per cent were hesitant, being impressed with the importance of a wider knowledge of the results and methods of science, but also with the difficulties in the way of success in such an undertaking as that suggested; and that about five per cent were positively hostile to the idea either from conviction that it could not be carried out, or that if it could be its success would be useless if not harmful.

The conclusions thus reached warranted, it was felt, efforts toward putting the idea into execution. The consultations, conferences and correspondence had up to date contributed one particular item of enlightenment for the first positive step. No new general large organization should be made. As far as possible organizations already in existence should be utilized. A widespread feeling was manifest among scientists that organization in science was already overdone. A small corporate working body representative of existing organizations seemed the desirable thing.

But even a single representative from each scientific society, were all those of the country to be counted in, would make a body too large for the ends to be attained.

The immediate problem was, then, that of deciding what few scientific societies are most broadly inclusive of the scientific interests of the country and likewise best fitted to further the public service aims of the projected enterprise.

To deal with these and other formative stage questions, conferences of scientists and journalists were held during the spring, summer, and fall of 1920, two at Mr. Scripps's home, Miramar, California, and two in Washington, D. C. The outcome of these was the decision that The National Academy of Sciences, The American Association for the Advancement of Science, and The National Research Council were the organizations best fitted to serve as the preorganizational foundation for the new corporation, but that since the enterprise was to be vitally connected with journalism, the journalistic profession ought also to be represented.

Two important decisions as to general policy were reached by these preliminary conferences. One was that the educational work of the projected corporation need not be restricted in means to be used by the press, but might, as conditions should warrant, be extended to any instrumentalities whatever, school and college founding and operating excepted.

This enlargement of possible agencies to be used had particularly in view, though by no means exclusively so, moving pictures, lectures, and conferences.

The other decision as to policy concerned the fields of science to be included in the activities. After ample consideration it was unanimously agreed that at present "only subjects in the natural and physical sciences and their applications" shall be within the scope of the corporation's work. The aim here was to exclude the humanistic sciences which, as now conceived and, to a large extent practiced, are subject to much passionate controversy, largely because dealing with "groups of material to which precise criteria of demonstrable evidence cannot be applied."

But the main outcome of these meetings was a provisional organization consisting of six persons as follows: Dr. George E. Hale, representing The National Academy of Sciences, Dr. D. T. MacDougal, representing The American Association for the Advancement of Science, Dr. R. A. Millikan, representing The National Research Council, and Mr. E. W. Scripps, Mr. R. P. Scripps, and Dr. Wm. E. Ritter, representing E. W. Scripps Estate.

This provisional organization invited each of the three foundation scientific organizations to nominate two additional members for the final corporation, thus to make nine scientists in all from these organizations. It also provided that the E. W. Scripps Estate should have three representatives; and, finally, that the journalistic profession should be represented by three members. It being found on inquiry that the field of journalism contains no organizations comparable with the three foundational organizations in science, the provisional organization requested Mr. E. W. Scripps to nominate the three representatives from this field.

Provision was also made by the pre-corporation that as soon as the additional nominations were made, further meetings should be held for the purpose of giving the corporation its completed working form.

These final organizational meetings took place in Chicago in December, 1920, and in Washington in March, 1921.

The outcome of these was *Science Service* as it now makes its bow to the public, and declares itself to have one and only one central ambition, namely, that of serving the public in the broad sense of contributing to its welfare, and not in the technical sense of syndicating scientific "stories" for its own profit.

The initial membership of the Service follows:

Representing *The National Academy of Sciences:*

Dr. A. A. Noyes, Director, Chemical Research, California Institute of Technology, Pasadena, California.

Dr. R. A. Millikan, Professor of Physics, University of Chicago, Chicago, Illinois.

Dr. John C. Merriam, President, Carnegie Institution of Washington, Washington, D. C.

Representing *The American Association for the Advancement of Science:*

Dr. D. T. MacDougal, Director, Desert Laboratory, Carnegie Institution of Washington, Tucson, Arizona.

Dr. J. McKeen Cattell, Editor *Science* and *The Scientific Monthly*, Garrison-on-Hudson, New York.

Dr. George T. Moore, Director, Missouri Botanical Garden, St. Louis, Missouri.

Representing *The National Research Council:*

Dr. Vernon Kellogg, Permanent Secretary, National Research Council, Washington, D. C.

Dr. George E. Hale, Director, Mount Wilson Solar Observatory of the Carnegie Institution of Washington, Pasadena, California.

Dr. R. M. Yerkes, Chairman, Research Information Service, National Research Council, Washington, D. C.

Representing the *Journalistic Profession:*

Mr. Edwin F. Gay, President, *New York Evening Post Company*, New York City.

Mr. Chester H. Rowell, former editor and manager, *The Fresno Republican*, now member California Railroad Commission, Berkeley, California.

Mr. William Allen White, editor and manager *The Emporia Gazette*, Emporia, Kansas.

Representing the *E. W. Scripps Estate:*

Mr. E. W. Scripps, Miramar, California.

Mr. Robert P. Scripps, Cleveland, Ohio.

Dr. Wm. E. Ritter, Director, Scripps Institution for Biological Research of the University of Calfornia, La Jolla, California.

The funds of the corporation are not represented by stock but their legal custodianship is a board of trustees the membership of which is now coincident with the membership of the organization.

The officers of the Service are a president, vice-president, secretary and treasurer, and an Executive Committee of five, one from each foundation body, in the hands of which are placed the detailed affairs of the Service. The vice-president of the corporation is chairman of the Executve Committee.

The first officers are: President, Wm. E. Ritter; Vice-President and Chairman of the Executive Committee, Vernon Kellogg; Secretary, Edwin E. Slosson; Treasurer, Robert P. Scripps.

The Executive Committee is: Chairman, Vernon Kellogg; members, Messrs. Cattell, Gay, Merriam and Ritter.

The first vital business to be done by the corporation was to select an editor and a manager, the two work officials which, it was provided, should be the initial operative portion of the service.

After much searching and great weighing of needs and abilities, Dr. Edwin E. Slosson was chosen Editor, and Mr. Howard Wheeler, Manager.

Dr. Slosson's quite unique standing in America, as a fully accredited scientist and at the same time as a litterateur of distinction, made the final action in his favor decisive. Mr. Slosson holds a doctor's degree in Chemistry from the University of Chicago, and was twelve years Professor of Chemistry in the University of Wyoming, which position brought him into familiar terms with several other branches of science. Following this he was for seventeen years literary editor of *The Independent*, New York. During this period he devoted much time, with great conviction of the importance of the task, to writing popular science. Some of the main fruits of this period in the form of books were: "Great American Universities"; "Major Prophets of Today"; "Six Major Prophets"; "Lives of Rumford and Gibbs"; "Easy Lessons in Einstein"; and, most notable of all, "Creative Chemistry." Lectures as Associate in the School of Journalism, Columbia University, were also part of his activities in these years.

Manager Wheeler's experience on the managerial side of journalism has been quite as varied as Mr. Slosson's on the editorial side. The editor-and-managership of the *San Francisco Daily News;* managership of the Pacific Coast department of the Newspaper Enterprise Association; managing editorship of *Harper's Weekly;* managing editor and later editor of *Everybody's Magazine;* and war correspondent, constitute the inventory of his journalistic activities. He is also the author of "Are We Ready?" a pre-war book on the preparedness question of the United States.

## CHEMICAL INDUSTRY IN CZECHO-SLOVAKIA

SINCE the foundation of the Czecho-Slovak Republic its chemical industries have appreciably recovered from the depression which prevailed during the war; they are well organized individually and also form part of a larger association, the Federation of Czecho-Slovak Industries at Prague. The chemical factories were mainly erected in Bohemia and Moravia, doubtless owing to the excellent transport facilities afforded by the Elbe and the Moldau. Important fertilizer plants are located at Kolin, Slany, Prerau, and Brünn, and those at Slany and Prerau also manufacture glue. Pharmaceutical products are made at Chrast, near Chrudim, and in Prague acids and explosives by the Nobel Dynamite Co. at Bratislava, and paints, varnishes, and shellac at Usti (Aussig). Mineral colors, especially ultramarine and Paris blue, chrome, and zinc colors, are made in many Bohemian towns, and coal-tar dyes are produced by the Aussig Chemical Co. at Usti, and by Kinziberger and Co. at Prague. The dye industry is not firmly established, German competition having proved too formidable in spite of a special high tariff. Ink is made by many firms, and at Ceske Budejovice (Budweis) is the famous plant of L. C. Hardtmuth, making pencils and colors. The manufacture of shoe-blacking is rapidly developing chiefly in North Bohemia. Factories producing greases, oils, essential oils, etc., are found chiefly near the large towns; before the war the production of vegetable oils, *e.g.*, linseed oil, was an important industry in Bohemia, but recently it has had to face competition from the cheaper fish and mineral oils. The soap industry has also suffered from foreign competition, and, since the war, from the liquidation of Government supplies of fats and oils; the largest factory is that of G. Schicht, near Usti, which employs more than 4,000 workers. Starch and starch-products are made almost entirely in Moravia and the adjoining parts of Bohemia.—U. S. Com. Rep., Jan. 21, 1921.

# Notes on Science in America

## Abstracts of Current Literature

Prepared by Edward G. Spaulding, Ph.D., L.L.D., Professor of Philosophy, Princeton University

### PHYSICAL OCEANOGRAPHY

In the *Journal* of the Washington Academy of Sciences for March 19, 1921, Mr. A. L. Thuras discusses the problem of physical oceanography.

Physical oceanography, says Mr. Thuras, is that branch of oceanography which deals with such physical properties of the ocean as temperature, salinity, density, pressure, velocity and direction of water movements, for the purpose of solving the general problems of oceanic circulation.

During recent years much work of an explorational nature has been carried on in the coastal waters of the United States and Canada. Dr. Henry B. Bigelow, in coöperation with the U. S. Bureau of Fisheries, has made these investigations, and the results of his work are published in the Bulletins of the Museum of Comparative Zoology, Harvard University. Several theories of the origin and circulation of our coastal waters have been corrected, and sufficient data have been collected to give a general working knowledge of the subject. Valuable observations have also been collected by observers in Canadian waters, and from these observations some exceedingly interesting theories of ocean circulation have been developed by J. W. Sandstrom.

Since the beginning of the International Ice Patrol an opportuunty has been given to extend this work farther out into the North Atlantic in the region of the Grand Banks of Newfoundland and in the Labrador Current and Gulf Stream. The conflict of the Labrador Current and Gulf Stream south of the Newfoundland Bank causes greater changes in the physical properties of the sea water, only a few miles apart, than occur in any other part of the world. From the data obtained and the admirable current charts prepared by Captain C. E. Johnston of the Coast Guard, a fairly accurate knowledge of the movements of ice after passing Newfoundland is available.

In the spring icebergs from the shores of Greenland and Labrador are carried southward in the Labrador Current, their movement being little affected by winds on account of their small buoyance. Those bergs which are sufficiently off shore to clear the bottom and keep in the south-flowing branch of the Labrador Current are carried along the eastern edge of the Newfoundland Bank and southward toward the Gulf Stream. By measurements of temperature and salinity the course and extent of these streams can be determined, salinity generally being the most reliable indication. The temperature of the Labrador Current is —1° to + 1° C., with a salinity of 33 grams of salt per 1,000 grams of sea water; the Gulf Stream has a temperature of 15° to 20° C., with a salinity of 36. South of the Grand Bank, where the Labrador Current merges into the Gulf Stream, a large area of mixed water is formed, and at this place the Labrador Current ceases as an individual current. In this mixed water almost all the icebergs remain until they melt, and, as this area is usually very foggy from the mixing of the warm and cold waters, it becomes extremely dangerous for vessels. At no time during the last four years has an iceberg ever been located in the unmixed waters of the Gulf Stream, which have a salinity of 36 and a temperature above 15° C.

A comparison of the yearly observations show that the volume and strength of the Labrador Current have a decided influence on the course of the Gulf Stream in this vicinity. In some years the Gulf Stream was found almost up to the southern end of the Grand Bank, in other years as far south as the 40th degree of north latitude, a variation of over 100 miles. This variation in the deflecting power of the Labrador Current must have an effect on the volume of flow of the Gulf Stream to the eastward and also possibly west of this position.

In order to obtain a clearer and more complete understanding of the dynamics of ocean circulation, an effort has been made in recent years to develop recording instruments. Hans Pettersson of Göteborg, Sweden, has built a photographic recording current meter which will give a continuous record of current velocity and direction for a period of two weeks. By the use of special anchors and buoys the instrument can be firmly anchored at any depth up to several hundred meters. Dr. R. A. Daly of Harvard University has recently constructed a thermograph which can be used at great depths in the ocean, and which will give a continuous record of temperature for a week or more. The U. S. Coast Guard in conjunction with the Bureau of Standards has designed and constructed a recording salinity apparatus and a recording thermometer which will give continuous records of temperature, salinity and density of the sea water taken from intake pipes below the surface by a moving vessel.

The physical oceanographic observations collected in our Atlantic waters indicate that that stage in development has been reached which calls for more thorough plans of work extending over a long period of time. These investigations can be accomplished most successfully by international coöperation, development of physical oceanographic instruments, and establishment of a permanent oceanographic laboratory.

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### THE MOVEMENT OF ROCK MASSES

Within the zone accessible to observation movements of rock masses are accomplished by fracture and flowage. These processes may be distinct and separate, or so interrelated as to make definition difficult. The zones of movement are many, their positions and attitudes diverse. In general they indicate shearing or grinding movements between rock masses, accomplished both by fracture and flowage, and caused by stresses inclined to the zones of movement. This conception is taken to afford the best initial basis for the interpretation and correlation of observed rock structures. There is no certain evidence of increase or decrease of movement toward the bottom of this zone. Beyond a shallow surface zone, there is no certain evidence of increase of rock flowage and decrease of rock fracture with depth. There is no certain evidence in rock flowage that pressures are dominantly hydrostatic or dominantly those of competent solid bodies.

Movements are known to occur in the zone below our range of observation, but their nature and distribution are the subjects of varied hypotheses based on a few known conditions. Much of the sharper diastrophism seems to be confined to a thin surficial zone. Deeper movements, of a more passive type, periodic and possibly slower, seem to be implied by the relative movement of great earth segments as represented by continents and ocean basins. Their depth is unknown. Most of the current hypotheses agree in assuming a single mobile zone in which rocks move dominantly by rock flowage. The basic requirements of reasonable hypothesis, however, may be equally well met by a conception of movement much like that of the zone of observation. This does not require or postulate the conception of the existence of any single mobile zone, or zone of slipping, or zone of flowage, or of an asthenosphere. It supposes movement irregularly distributed in many zones, with any inclination, and accomplished by both fracture and flowage as far below the surface as movement extends—always remembering that some of the structures geologically described as fractures, may be expressions of mass movement of the kind defined as flow in experimental results.

Conditions of temperature and pressure and vulcanism become more intense with depth, but it remains to be shown that their conjoint action results in a uniform environment, and even if it does, that this condition is not upset by what might be called a heterogeneity of the time factor as represented by differing rates of deformation. If homogeneous environmental and time conditions are assumed, it is yet to be shown that these are sufficient to overcome the heterogeneity of the physical properties of the rocks and to cause homogeneous behavior through any considerable zone. It is not even certain that they may not fix and accentuate the heterogeneous properties of rocks. Certainly in the zone of observation there is comparatively slight evidence of their efficacy in causing more uniform deformation with depth.

In short, as between alternative conception as to the conditions in the deep zone, the burden of producing affirmative evidence would seem to rest heavily on any conception involving radical departure from the known irregular distribution and manner of movement within our zone of observation. We come, therefore, to the conception of a heterogeneous structural behavior of the earth.—Abstract from article by Dr. C. K. Leith of the University of Wisconsin, *Science*, March 4, 1921.

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## THE PRACTICAL VALUE OF ANTHROPOLOGY

IN an important article in *Science* for February 18, 1921, Prof. A. E. Jenks discusses the Practical Value of Anthropology for the nation.

Stated broadly the bed-rock national anthropological problem, says the author, is the survival and improvement of the human element of our nation. The *sine qua non* of civilization at any time is man's survival on physical, intellectual, and moral planes as high as those he possessed at that time. Civilization is lost to the extent that man's survival-planes are lowered. The goal of civilization seems to be for increasing numbers of mankind to survive on more elevated planes of mutual, physical, intellectual and moral freedom. It appears to be a part of cosmic evolution for each generation to press toward that goal. But to a large extent even today our generation is pressing blindly toward this goal with its mind on remedial factors rather than on causative factors.

Ethnic groups differ one from another. They differ beneath the skin. We know, for example, that the processes of pigment metabolism are so unerring and persistent that patches of skin taken from one person and grafted on another take on the proportion of pigmentation natural to the "stock" or seat on which the transplanted skin lives. We know also that ethnic differences are so much more than only "skin deep" that ovaries transplanted from one person to another person would reproduce children of their own kind without influence by the person who served as "stock" or seat for the transplanted ovaries. There are, it must be granted, no experiments of this sort, but what has been proved true with other animals would without question be true of human animals. Thus there is scientific reason to speak of different "breeds" of people whose differing physical characteristics are today due to the factors resident in the reproductive germ cells. Ethnic differences are not simply "skin deep." They are germinal. They begin at the functional innermost center of the person, and they continue through to the outside. The man who runs sees the outside differences between breeds of people. The anthropologist knows they begin inside in the seeds of the breeds.

The American immigration problem is centered in the various breeds of people who are clamoring to come to our shores or who are already in our midst. What facts and tendencies of strength and weakness for the future of the American nation are in those various ethnic groups? On the answer to this question hinges the whole immigration problem. It is a question for the most careful study, the accumulation of accurate data, and for effort at scientific conclusions on the part of anthropologists in order that an intelligent public opinion based on known facts, instead of sentiment or prejudice or commercial profits for the few, may dictate our policies and practise in regard to the people coming to us or already here.

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## THE ORIGIN OF THE MECHANISM OF HEREDITY

DR. MERLE C. COULTER of the University of Chicago presents in the *Botanical Gazette* for December, 1920, an important discussion of the problem of the Origin of the Mechanism of Heredity.

It seems safe to assume, says Dr. Coulter, that the most primitive organism lacked not only an organized nucleus, but even the components of a nucleus. A consideration of the activities of such an organism will, however, reveal a suggestion as to the origin of the hereditary mechanism.

The metabolism of this primitive organism, in certain fundamental features, will be similar to that of all organisms. Raw materials will be taken in and transformed to provide building materials and energy. If the raw materials be pure and the machinery of the protoplast perfect, this transformation will be complete, so that all the raw materials taken in will be transformed and used. Actually, however, the raw materials provided are never quite pure, and the machinery of the protoplast, although infinitely more efficient than any man-made machine, must be subject to certain flaws and frictions of its own. The transformation and use of materials, therefore, will not be complete; certain waste materials and *by-products* will remain. It is now the fate of the by-products which is significant.

Certain of the by-products may be insignificant in their influence upon the protoplast. Others will undoubtedly be toxic in their effect, as many investigations upon auto-intoxication have gone to show. Primitive excretory systems, developed primarily for the disposal of waste materials, may remove a considerable part of these by-products. Thorough cleansing of the protoplast by this method, however, is impossible. Inevitably by-products will accumulate with the age of the organism. In fact age itself, in other than the purely chronological sense, is probably accounted for by this very accumulation of by-products. The toxic influence of these by-products will interfere with the efficient working of the machinery of the protoplast, and metabolism will be slowed down; hence "old age." Rejuvenescence occurs with cell division, because at cell division the protoplast is cleansed of many of these toxic by-products. This cleansing probably involves both physical and chemical forces. Physical reorganization at cell division will explain the exposure of these by-products; chemical oxidation will account for their removal (as toxins).

Again, were the machinery of this cleansing process a perfect one, rejuvenescence would be complete. Actually, however, the cleansing of the protoplast at cell division is not (or is not always) absolutely thorough. A few of the by-products pass over to the daughter protoplasts. The daughters, therefore, start life with a few by-products which the mother did not possess at the beginning of her life. Since these by-products are toxic and impair or retard metabolism, it is evident that the daughters are, at birth, slightly "older" than was the mother.

A series of repetitions of this performance through successive generations will have a cumulative effect. As a consequence, not only does the individual grow old through ontogeny, but, in a very real sense, the whole race is gradually aging through phylogeny. Evidence is not lacking that the higher organisms, cell for cell, have a lower rate of metabolism than do the more primitive ones. This is a statement of the quantitative effect of these by-products. It is their qualitative effect, however, that casts light upon the origin of the hereditary mechanism.

The by-products which originally accumulated in the protoplast were of various types. Some were very toxic and these, if they were not immediately eliminated, resulted in the death of the organism. Others were less toxic, relatively more harmonious with the protoplast itself. These last, since they were

not immediately fatal, stimulated an adaptive response on the part of the protoplast.

As to the general nature of this adaptive response, an important assumption must be made. Recent researches upon mammals have revealed in these organisms the power to develop antitoxins. This power is probably one of the fundamental characteristics of all protoplasm, being present even in the most primitive organisms.

Certain by-products in the primitive organism, only slightly toxic in their effect, stimulated it to produce an antibody. The antibody counteracted the influence of the toxic by-product by insulating it from contact with the protoplast. Antibodies were probably developed most successfully for those by-products which were the least toxic in their effect. These by-products then became insulated by the antibodies. This insulation was significant not only in cutting off the influence of the by-product upon the protoplast, but in another respect also. At cell division this by-product, even though exposed, is not oxidized because of the protection afforded by the antibody which insulates it. It is probably this mechanism, for the most part, which accounts for the fact that some of the by-products are passed on to the daughter protoplasts, as mentioned before. *These by-products are the primitive bearers of hereditary characters.*

This theory accounts for the origin of the hereditary mechanism in terms of by-products and antibodies which insulate them. These various antibodies must form an important constituent of "modern" chromosomes, but there must also be present some more stable and homogeneous framework.

The origin of a given by-product is accounted for by chance environmental conditions. The environment referred to may well have been the external environment in the case of the simpler organism, but must be the internal environment in the more complex. This seems also to provide sufficient basis to explain the small degree of inheritance of acquired characters.

# Research Work of the United States Bureau of Standards

## Notes Specially Prepared for the SCIENTIFIC AMERICAN MONTHLY

### THE FIRE RESISTANCE OF BUILDING MATERIALS

ONE of the most interesting sights which may be witnessed at the Bureau of Standards is in connection with the investigation of the fire resistance of various building materials. Moreover, this work is of the greatest possible importance and should go a long way toward improving building construction. Believing that in order to reach sound conclusions in investigational work, it is necessary to duplicate conditions met with in actual service, the Bureau has constructed apparatus by means of which it is possible to subject a full sized wall to the intense heat existing during a conflagration.

In order to accomplish this end a furnace has been constructed, closed by permanent walls on three sides, while the fourth side is made up of a removable steel framework like a large picture frame within which may be constructed a panel or wall of the material to be tested. The dimensions of the panel which may be erected within this frame are 16 feet long by 11 feet high. The entire framework containing the panel may be moved by a suitable crane so as to admit of easy access to the interior of the furnace. At the base of the furnace are two burners supplied with fuel oil and air by means of regulating valves and a motor-driven blower. Temperatures at different points within the furnace and in the wall or panel are measured by thermocouples so that the degree of heat attained after a given length of time in different portions of the material being tested may be easily observed. The usual way in which one of these tests is conducted is as follows: Suppose a brick panel is to be investigated; the wall is built up within the steel framework using the desired bricks and mortar and with an average quality of workmanship so as to insure conditions similar to those met with in service. The wall is then allowed to stand for several weeks in order to insure the evaporation of moisture. After this period is over, the fire test is carried out. The framework with the brick panel is placed in position so as to close up the furnace, the fuel and air turned on, and the temperatures recorded after definite periods. Usually the panel is subjected to the fire test for a definite length of time, say, 6 hours, and if it does not break down before the expiration of the period, the framework containing the panel is removed from the furnace to permit examination of the side exposed to the fire. The maximum temperature attained in the furnace may reach 2,000 or 3,000° F., but with a wall of good construction the temperature of its exterior surface should be below that of most combustible materials. Fusing and cracking of the material, warping due to expansion, etc., are all taken into account in determining the value of the wall as a fire-resisting medium.

A test of this sort is being conducted approximately each week at the Bureau and the whole will form an elaborate study of fire resistance which should prove of the greatest value to builders and architects.

### A NOVEL TYPE OF BOLT

RECENTLY one of the government departments requested the Bureau to investigate various means for fastening two heavy steel plates together in a situation where ordinary bolts and rivets could not be used. Two means were suggested for accomplishing this object: one was by inserting a pin which under normal conditions would have a diameter slightly in excess of the holes in the plates and which by some means could be contracted sufficiently to enter the holes; while in the other a pin or bolt was to be used having drilled along its axis a small hole in which an explosive charge could be inserted, the idea being that the bolt would be an easy fit in the plates and would afterward be expanded by the explosion of the charge.

Practical experiments using both means for accomplishing the object were tried at the Bureau of Standards. The first method tried was by the use of liquid air; the pins were about 0.001 inch too large for the holes and were immersed in liquid air until they could be driven into the plates rather easily. As the pins warmed up they became a tight fit. When the strength of the joints thus secured was determined in the Bureau's testing machines, it was found that it would meet the requirements. In the second method, that using the explosive charge, a strength almost as great was obtained.

The practical application of these methods, of course, may not prove as satisfactory as has been indicated in the tests, but it is of considerable interest in any event.

### A CAUSE OF AIRPLANE ENGINE FAILURES AND DISASTERS

UNQUESTIONABLY a snow storm may cause a plane to crash. The assertion that a plane may come to grief from a snow storm of which it itself is the cause is, nevertheless, startling. Recent experiments at the Bureau of Standards have shown such an occurrence to be by no means impossible. This snow storm, however, is not one that is seen by the pilot, but one that takes place in the intake manifold of the engine.

Since the altitude laboratory makes possible the testing of airplane engines under service conditions, it is to be expected that many of the troubles occurring in service will be experienced in these tests. Laboratory tests offer exceptional opportunities for tracing such troubles to their origin, because under such conditions so many more quantities are measured than in service. This instance furnishes an excellent illustration.

During some of the Bureau's investigations, when the existence of trouble became apparent from a decrease in engine power, measurements showed the rate of air flow to have decreased as would have been the case had the drop in power been occasioned by closing the throttle. Tests in the carburetor test plant had shown that such a throttle action might be produced by the formation and collection of snow in the induction system. The snow itself had been observed through a glass section of this system. Snow thus appeared a very probable source of the difficulty.

To form snow, two conditions must be met: (a) Moisture must be present and (b) the temperature must be low enough to freeze this moisture. Indirectly, both of these conditions may be satisfied by the vaporization of fuel in the inlet system. This vaporization requires heat, much of which is supplied by the mixture. As a consequence, under certain conditions, the temperature will drop below the freezing point. A decrease in temperature decreases the weight of water vapor that a unit volume of air can contain and the surplus condenses. Hence, the temperature drop produced by the vaporization of the fuel may result both in the condensation of moisture and lowering the temperature to the freezing point of water, and hence satisfy both conditions necessary for the formation of snow.

Actual proof that snow was the source of trouble was not hard to obtain. The test equipment is so arranged that the air passes over heating grids on its way to the engine. In creasing the air temperature 20° C. or more by this method cured the trouble in every instance. The set-up also permits the air for the engine to be taken over refrigerating coils, thus being cooled to a temperature so low that it can contain almost no moisture. This air is then reheated to the desired temperature. It was found that air so treated permitted satisfactory engine operation at those temperatures where trouble was encountered with the air from which the moisture had not been removed.

It will be readily appreciated that the starting point of this trouble is the drop in temperature brought about by the vaporization of the fuel. The cure obviously is to supply sufficient external heating to prevent this temperature drop. How much external heating is necessary to attain this end can be calculated from knowledge of the heat of vaporization of the fuel.

The chief danger from this source is not that it causes a decrease in power, but that it results in violent fluctuations of power which can neither be predicted nor controlled by the pilot. These fluctuations are produced when fragments of the snow are dislodged and result in changes of speed similar to those produced by suddenly opening the throttle. Moreover, if such trouble is instrumental in causing disaster to the plane, the snow will all melt before the engine can be torn down for examination. There is then left nothing to substantiate the pilot's report of engine trouble.

There is an unfortunate tendency to attribute all accidents for which no satisfactory explanation can be found to the fault of the pilot. It is believed that the above information will explain some of these disasters for which pilots have been unjustly blamed.

## PARTIAL IMMERSION THERMOMETERS

Most of the thermometers made and sold for laboratory use in this country have been of the so-called total immersion type, that is, they were pointed and graduated to read as nearly as feasible correct temperatures when immersed so that the bulb and the whole of the mercury column were at the same temperature. It is only in rare cases, however, that thermometers, especially those used at high temperatures, are immrsed more than a few inches. Under such conditions the thermometers read too low, and a so-called stem correction should be applied. However, the proportion of those engaged in chemical or similar work in this country, who are both able and willing to go to the trouble of calculating and applying such stem corrections, is perhaps 1 in 10,000. It is, therefore, in general preferable that partial immersion thermometers should be used in ordinary laboratory work. This year for the first time the General Supply Committee has specified partial immersion thermometers for general use in government laboratories and the American Chemical Society's committee on Guaranteed Reagents and Standard Apparatus has recommended the use of the same specifications which were prepared by the Bureau of Standards. A note on total and partial immersion thermometers in which the advantages and disadvantages of the two classes of thermometers are set forth has been published in the *Journal of Industrial and Engineering Chemistry* for March, 1921.

## SMOKE MASKS FOR USE OF THE DISTRICT OF COLUMBIA'S FIRE DEPARTMENT

A request was received from the District of Columbia Fire Department to assist the Chief Engineer in the preparation of specifications for smoke masks and in training the men in their use. A special "smoke house" is being equipped for this purpose. Conferences with the Chief Engineer have been held and plans for the work have been made. The characteristics of different types of masks have been discussed in relation to requirements for fire fighting and comparative tests on them will soon be made. Valuable advice on the smoke aspect and the illuminating gas aspect of this question has been obtained from two specialists in these subjects who were connected with the Chemical Warfare Service during the war.

## RECENT CHEMICAL PUBLICATIONS

"The Determination of Iron by the Cupferron Method" by G. E. F. Lundell will appear in the April number of the *Journal of the American Chemical Society.*

"The Determination of Cobalt and Nickel in Cobalt Steels" by G. E. F. Lundell and J. I. Hoffman has been accepted by the *Journal of Industrial and Engineering Chemistry.*

## NATIONAL ELECTRICAL SAFETY CODE

Handbook No. 3 of the Bureau of Standards has recently been published and may be obtained from the Superintendent of Documents at 40 cents per copy. This new addition is a book of pocket size and the discussion of the rules has been segregated in a separate volume which will appear later as Handbook No. 4.

In addition to two introductory sections giving definitions of terms and rules for the grounding of apparatus and circuits, the Code consists of four principal parts as follows:

(1) Rules for the installation of machinery, switchboards, and wiring in central stations and substations; (2) rules for the construction of overhead and underground lines for the transmission and distribution of electrical energy and intelligence; (3) rules for the installation of electrical apparatus and wiring in factories, residences, and wherever electricity is utilized for light, heat, or power; (4) rules for safeguarding employees when working near electrical machines or lines.

This code has been developed with the coöperation of all interests concerned. It has been thoroughly revised for this edition and many of the rules have been made mandatory in several states. Their use will, no doubt, be greatly extended now that the new edition of the code is available; they are being used voluntarily by a large number of utility companies.

# Progress in the Field of Applied Chemistry

## Notes Culled from Current Technical Literature

By H. E. Howe, Member of American Chemical Society

### INFLUENCE OF COPPER UPON THE SOLUBILITY OF IRON

BELL AND PATRICK in the March Journal of the American Chemical Society discuss the results of their experiments on "The Influence of Copper on the Rate of Solution of Iron in Acids." There has been much debate upon the effect of the presence of the small amount of copper in iron as regards the corrosion of that material. For example one experimenter reported that two-tenths of a per cent of copper materially decreased the corrosion of steel sheets under atmospheric conditions, while another declares that many investigators have deceived themselves in concluding that so small a percentage of copper makes steel more resistive. The present authors undertook a study of the rate of solution in hydrochloric and sulfuric acids of various concentration and prepared alloys containing one-tenth %, three-tenths %, five-tenths %, one % and five % of copper. Due to the slowness with which dilute acids attack alloys of this type the experiments were conducted with concentrated acids and this was necessary since the method employed involved measurement of the rate of gas evolved due to the reaction between the acids and the metals. The rate of solution of pure electrolytic iron and pure reduced iron were compared with that of the copper alloys and under the conditions of the experiment the alloys showed a definite decrease in solution.

### ASSAY OF COAL FOR CARBONIZATION PURPOSES

A NEW laboratory method for the assay of coal for carbonization purposes is the subject of Technical Paper No. 1, Fuel Research Board, Department of Scientific and Industrial Research, Great Britain. For some time there has been need for a method of coal analysis in which by direct weighings and measurements the yields of gas, oil, water and carbonaceous residue resulting from the carbonization of coal at definite temperatures could be quickly and accurately determined. Some laboratories have practised the distillation of samples of coal on a small scale and while no new scientific principles are involved in the new method reported, still, a standardization has been obtained by means of which coals can be classified with a precision not heretofore possible.

The apparatus consists of a glass retort which resembles a distillation tube in which a charge of coal of 15 grams is placed. This small retort is connected to a Leibig bulb which acts as a condenser for the reception of the liquid products, a tube filled with glass beads and sulfuric acid for the absorption of ammonia, and a gas holder connected with a reservoir counterbalanced so that as the gas enters displaced liquid passes into the reservoir, thus maintaining automatically a constant pressure in the holder.

The electric furnace which the retort has heated is mounted upon rollers so that the charged tube may be placed in position with great ease after the furnace has been heated to 300° C. As soon as the evolution of gas occluded by the coal and of expanded air stops the temperature of the furnace is gradually raised so that the ultimate temperature of 550 to 600° C. is reached in one hour. During this period observations are made of the temperatures at which water and oil appear. Heating at the final temperature is continued for an hour at the end of which time the rate of gas evolution has fallen so that further heating gives a practically negligible addition to the volume.

The yield of coke is obtained by weighing the hard glass retort tube with its contents. The Leibig bulb shows the yield of water and oil by its increased weight and the volume of the aqueous portion is measured by washing the contents into a 10 cc. graduated cylinder 8 with chloroform or petroleum ether. The contents of the sulfuric acid tube are mixed with the aqueous washings from the Leibig bulb and distilled to give the yield of ammonia and bases. The gas volume is easily ascertained.

Checks upon coal assayed by various methods indicate that the sample method can be accepted as a satisfactory means of testing coal for carbonization. The paper gives tables of results as well as drawings of the apparatus and full directions for the use of the method.

### GLUE ANALYSIS

THE March number of the *Chemical Bulletin* in the series of guides to analyses gives a discussion by Charles R. McKee on the interpretation of glue analysis. The following is quoted:

"*Viscosity* and *Jelly Strength* have been discussed in the various texts and journals and are used as a main guide in determining the quality of the glue. By comparing standards or type samples with the one under investigation the relative grade can be determined. The oil viscosimeters on the market are not adapted to glue testing due to the shallowness of the well, lack of uniformity of orifice in different instruments of the same make, lack of provision to replace the orifice tips in case of injury or corrosion, and also poor means of release of the liquor which occurs in some types. As a result nearly every glue manufacturer has devised his own instruments for determining viscosity and jelly strength, resulting in instruments of various degrees of success and of individual standards.

"The *foam test* is determined by stirring in some mechanical manner with the minimum loss of temperature, noting the volume and timing the duration of the foam. This has relation to the glue's behavior in mechanical spreading machines.

"*Keeping Quality.*—Glue is a nitrogenous material which easily serves as a culture medium for bacteria. Liquefying bacteria can cause a serious loss of quality in a short time and if cleanliness is not maintained by the user this loss can be carried forward from day to day by contamination. Many glue manufacturers add a small amount of antiseptic or disinfectant to their glues to avoid bacterial invasion. Where a glue liquor is held some time it is of interest to know how well the liquor will keep. This is determined by maintaining a sample of the liquor at 98° F. and noting the number of hours the glue remains 'sweet.' The addition of a suitable germicide by the user does not injure the quality when applied in reasonable quantity, but is not encouraged because it admits carelessness and slovenly methods, and also risks the use of injurious disinfectants.

"*Grease.*—Glue is a good emulsifier and may carry over grease in the process of manufacture. Grease in limited amounts is desirable in some work and again is objectionable in others; for example, it is undesirable in water paints and glass chipping. It can be determined quantitatively by careful hydrolysis with acid, mixing the residue with sand and extracting.

"*Nitrogen* is determined when a non-nitrogenous adulterant, such as dextrine, is believed to be present, or to determine the percentage of glue in a composition. The nitrogen determination is not a guide to grade.

"*Ash* is determined to detect adulteration or faulty manufacture. However, adulteration of this kind is rare.

"*Sulphur and Sulphides* are looked for when the glue is used for silverware wrappings (sizing) or containers.

"The following are not of great value as standards, be-

cause of the personal equation, skill required, influencing factors, or even absence of merit.

"*Joint Test.*—Within reasonable limits all good grades of glue will give a glue joint stronger than the wood itself, providing that the joint has been carefully made. In other words the joint test will reflect the condition of the wood, the contact of the surfaces and the manipulation.

"The success of many glue salesmen lies largely in their ability to understand the three above conditions, and if possible, supplying a glue to meet them.

"The *color* and *thickness* of a flake of glue are of little value in determining the grade.

"The *fracture* of a piece of glue is claimed to indicate quality but much experience is required to appreciate this. Moisture influences the fracture to a marked extent, so that little confidence can be placed on this test.

"The *shape* of the pieces of glue is no measure of its value. For example, 'noodle glue' has not special merit.

"*Streak.*—Some consider glue good when it forms a white streak on bending; it is needless to say that almost any glue will streak if it has enough moisture.

"*Finger Test (Jelly).*—Perhaps the test that the glue maker takes the most personal pride in is his ability to tell the quality by the feel and firmness of a congealed sample. In fact, by continuous practice he does develop skill in judging but has no method of expressing the value in units.

"*Glass Chipping.*—The novice in this art will have a difficult time duplicating results as this work requires skill and standard conditions of drying. This test indicates nothing excepting that the glue is adapted to chipping glass.

"*Film Test.*—The casting of sheets on glass, stripping and drying is apt to lead to erroneous conclusions unless all factors of temperature, thickness, stirring, rate of drying and humidity are constant.

"*Brush Test.*—Pigment on dye is mixed with glue liquor and the mixture is brushed out on paper. This is supposed to indicate the amount of grease present in the glue, as the globules of grease will prevent the color to adhere in spots. The extent of spotting will depend on the character of the grease present and the state of division of the particles. Some glues are so greasy that the dry particles adhere together, yet they will not spot the paper. However this test is of value to makers of some types of cold water paints."

## A COMPARATIVE STUDY OF VIBRATION ABSORBERS

THE March number of the *Journal of Industrial and Engineering Chemistry* contains an interesting report of a study of vibration absorbers by H. C. Howard. All those concerned with the use of such sensitive apparatus as an analytical balance have been confronted with the problem of so mounting as to eliminate vibration which at times is so serious as to make results of no value. By the use of a kymograph the actual vibrations have been recorded, using the various devices which have been suggested for the elimination of vibration, these including air bags inflated to various pressures, rubber balls filled with air at forty pounds pressure, and various arrangements of these balls. These arrangements include balls held between strips of wood, two sets of balls separated by a frame, a series of three balls one above the other held in position by a section of pipe supported at its base by a flange and four balls piled in tetrahedral form, the three base balls being retained in place by a triangular wooden frame. Further, slabs of sponge rubber built up to a four-inch thickness were tried as well as those of cork and of felt.

It has always been held that some type of suspension involving a heavy frame work and considerable space and expense is the only satisfactory method for the elimination of vibration and it was with a view to learning whether a satisfactory substitute could be secured that these experiments were carried out. Of the various substitutes the tetrahedral arrangement of the rubber balls gives the best results although the spring suspension is markedly superior to any of the supporting devices developed. Such a suspension does have considerable vertical vibration and when the suspension and tetrahedron are used in combination considerable improvement is obtained.

## THE ACID PROCESS APPLIED TO TANNERY WASTE

E. S. DORR in a recent issue of *Public Works* discussed the Miles acid process applied to tannery waste. The sample submitted to the process was very high-colored and heavily charged with organic and mineral matter, which contained 4,886 parts mineral matter per million parts and 1,583 parts organic and volatile matter. Upon the application of sulphur dioxide the waste cleared quickly and settled well within half an hour. The black red color was changed to straw when 860 parts of sulphur dioxide per million were used and sterility could probably have been secured with 900 parts. The odor was completely eliminated and the reduction of organic and volatile matters including suspended solids was fifty per cent. The precipitated sludge amounted to 4 tons dry weight per million gallons of waste treated and with grease content of 16.88 per cent, ammonia 7.5 per cent, and in the degreased sludge the ammonia was 9 per cent. Expressed in pounds, there was recovered 1,644 pounds of degreased fertilizer material and 1,360 pounds of grease per million gallons of waste.

The values of the products have been estimated at from 291 to 331 dollars per million gallons treated and the cost for the treatment would amount to $161.22. The disposal of tannery waste has been a source of great concern and as far as the literature shows there has been no revenue from such waste heretofore. In addition, the fact that the sludge and the effluent are inodorous and that the color is so bleached that with reasonable dilution there would be nothing noticeable except at the outlet, and that the sterility in the effluent can be obtained, would seem to recommend further experiment with tannery wastes treated by the process in question.

## DECORATION OF PORCELAIN

IN the *Pottery Gazette*, H. Banard discusses the decoration of porcelain and the article is abstracted as follows from the *Journal of the American Ceramic Society*:

"True oriental porcelain is fired in the first firing only sufficiently to enable it to be handled and the hard firing takes place during the glost firing. In the case of hard porcelain and common stoneware the body and glaze are fired in one operation whereas soft porcelain, china, English bone china, and earthenware undergo two firings. Motor-driven polishing lathes are used to remove blemishes from glazed ware due to stilt marks, etc. Underglaze colors when examined under the microscope appear as fine powder. In printing a copper plate is engraved with a pattern which is then covered with an underglaze color. The surplus color is rubbed off. A piece of tissue paper sized with a water size is spread over this plate and the color is pressed on to the paper with a lithographer's press. The design is then transferred to the bisque ware which is then passed through a hardening-on kiln where it is fired just sufficiently to harden the color. The glaze is then put on and it is fired in a glost kiln. Overglaze colors are a mass of glass with metallic oxides differing from underglaze colors which contain no flux. For enamel colors certain metals may be used. Gold gives a pink and manganese gives an amethyst. Copper with a high soda glass gives turquoise and with a high lead glass, bottle green. The best gold decorations are made by grinding metallic gold with mercury. A flux of glass is used with the gold to make it adhere more firmly. In acid gold decoration the pattern is put on white glazed china with an oily acid resisting paint. The piece is then plunged in an HF bath where all exposed portions are partly etched by the acid. The paint is then removed and gold decorations applied all over the ware. After firing the piece is burnished, whereupon the pattern appears bright and the etched portion dull. Ground laying is a process by which an even coating of color is applied on ware in

whatever space is desired. For example a green vase with white panels is made as follows: The shape of the panels is painted on with resist-color—anything that will resist oil—which may be a mixture of treacle and color. A very sticky oil, such as boiled linseed, is then applied over the pot. Green enamel is then dusted on, there is just sufficient oil to take a certain amount of enamel and no more, thus producing an even tone. The pot is then immersed in water which removes the treacle and color but not the oil and enamel."

## FUTURE DEVELOPMENTS OF THEORETICAL CHEMISTRY

THIS was the subject of an address by Dr. Irving Langmuir on the occasion of the tenth birthday of the Chemists' Club, and those interested in new aspects of science are urged to read the address in full as it appears in the March 30th number of *Chemical and Metallurgical Engineering*. The discussion marks an important advance in theoretical chemistry and considers the possibility of reasoning out properties of as yet undiscovered elements and compounds and their reactions as based upon the structure of the individual atom. Dr. Langmuir points out the properties of chemical molecules which have been predicted by those unfamiliar with chemistry on the basis of certain fundamental principles regarding the stability of certain electrons. On this point the following is quoted from the address:

"I found a good deal of skepticism among these physicists as to what really could be done from such simple assumptions, until finally I proposed to one of the members who was most active in the discussion or criticism of the theory—in a constructive way, however—that he should answer the question himself as to what a physicist could deduce in regard to the properties: I therefore asked him what compounds there would be between hydrogen and lithium, and if he could tell me what the properties of that substance would be, if there is such a substance. He replied that he had no knowledge of any compounds of lithium and hydrogen; but by applying the fundamental idea that a pair of electrons around a nucleus will form a very stable configuration, and also by using his knowledge of Coulomb's law and other well-known electrical laws he was able in a very few minutes to derive these conclusions: That lithium hydride should have a formula LiH; that it should be a white crystalline solid body under ordinary conditions, a non-conductor of electricity when solid, but if molten should conduct electricity electrolytically, and hydrogen should appear at the anode, which is not where hydrogen usually appears. Now many of the properties of lithium hydride were not known until recently; but G. N. Lewis predicted those facts in regard to the electrolytic conductivity of lithium hydride, and only recently, within six months or so, Professor Nernst has had published an article on electrolytic conductivity of lithium hydride, showing that the hydrogen is liberated at the anode instead of at the cathode. Those were predicted in this case by a physicist who had never heard of lithium hydride, and doubted very much whether such a thing existed."

## CHEMICAL RESEARCHES IN DYESTUFF APPLICATION

THE following interesting announcement from the *Color Trade Journal* for March is quoted in order that those desiring to devote their efforts to researches in the dye field may become familiar with the present needs:

"The Society of Dyers and Colorists have a fund which is devoted to the development of chemical research in fields related to the application of dyestuffs. Below is given a list of proposed researches for which as yet no investigators have been nominated, and the Council of the Society is willing to make grants varying from £25 to £200 to competent investigators who are willing to undertake any of these researches.

"(1) The dyeing of kemps in woolen yarn or pieces;

"(2) The dyeing of a black on cotton yarn to stand a chlorine bleach, and to be fast to rubbing, at a cost not exceeding that of an ordinary aniline black;

"(3) The dyeing of dead cotton present in cotton yarn or piece goods;

"(4) An exhaustive study of the Foulard dyed style (tannin, caustic discharge, fix in tartar emetic, and dye in basics), with clear indication as to how the various difficulties can be overcome to insure regularity on the commercial scale.

"(5) A scientific investigation of the process of mordanting cotton cloth with aluminate of soda for full alizarin red;

"(6) A cheap and efficient means of fixing pigment colors in printing so that they shall stand boiling soap (see Manby's patent);

"(7) A practical method for the production of fast multicolor prints in combination with print-on indigo (glucose method);

"(8) A method of producing a yellow discharge on dyed indigo similar to that obtained with Leucotrop O, but fast to washing and light;

"(9) White and colored discharges on sulfide colors;

"(10) Colored resists, including red under aniline black, fast to strong soaping;

"(11) An investigation into the influence of the various finishing agents upon the resulting fastness to light of dyed leathers;

"(12) A method of application of sulfide dyestuffs in the dyeing of vegetable, chrome, and oil dressed leathers;

"(13) A method of manufacturing on a small scale a fat liquor emulsion, using any desired oil or fatty matter, without the employment of soap, sulfonated oil, or egg yolk as emulsifying agents;

"(14) A satisfactory method for the fixation of acid colors on cotton;

"(15) The production of a green by coupling with betanaphthol, which can be worked similarly to and in conjunction with para red;

"(16) An investigation into the cause of tendering that occurs during the lime boiling of cotton cloth, both in open and closed kiers;

"(17) A method of obtaining complete penetration of dye through thick leather, preferably employing acid dyestuffs, the leather to be dyed the same shade throughout.

"(18) The maximum amount of iron, ammonia, bichromates, sulfuric acid, and similar products that can be employed in the dyeing of various vegetable tanned leathers without having a detrimental action. Also the cause of the detrimental action these products produce;

"(19) Possibility of the production of a combination of synthetic tan and dyestuff to be used in one operation;

"(20) Scientific study of the ageing of iron mordants for production of dark shades in dyeing."

## DETECTING LEAKING GAS

CONSIDERABLE loss of life and property has resulted from the leakage of the distribution in natural gas and blue water gas used for fuel and illumination. The Bureau of Mines, therefore, undertook investigations looking to the employment of stenches to be added to the gas particularly in the case of blue water gas which is almost colorless and particularly dangerous, being poisonous due to the presence of nearly 35 per cent of carbon monoxide.

Leaks in pipes, particularly those in the open, are seldom detected until the loss of gas becomes appreciable and even then the leaks are difficult to find.

Technical Paper No. 267 of the Bureau of Mines has been issued and includes a description of an odorimeter which has been devised in order that the intensity of stenches may be measured and also gives in detail the chemical, physical, and physiological properties of chemicals which may be used as stenches. In summarizing the result of the investigation these statements are made:

"The impregnation of natural gas or blue water gas with a stench-imparting chemical provides a means for reducing loss from leakage and for eliminating accidental poisoning and

explosions. Measurements of the intensities of odors have been used to ascertain the quantities of stenches needed to impart a strong odor to gas and to calculate the costs. Use of the strong odor is advised. Stenches that possess a disagreeable odor serve best as warnings. Of those examined, amyl thioether, ethyl mercaptan, phenyl isocyanide, and pyridine present the best possibilities with regard to the cost of impregnation, as well as to other properties required.

"Gas can be uniformly impregnated with a stench by allowing it, when cleaned and still warm, to pass through a horizontal pipe into which stench liquid is delivered at a uniform rate. Gravity feed of the liquid can be used, but requires more supervision than mechanical appliances, such as engine lubricators. The lubricator manufactured by the Richardson Phoenix Co., of Milwaukee, Wis., is well adapted for gas impregnation. Gas can be impregnated by placing in the pipe at regular intervals a quantity of stench and allowing the natural mixing of gas in the gasometer to make a uniform concentration.

"None of the stenches that contain sulphur, if added to gas in amounts to produce strong odors, would carry sufficient sulphur to inhibit commercial use of the gas. The maximum addition of sulphur is 8.0 grains per hundred cubic feet of gas, imparted by ethyl mercaptan."

# Research Work of the U. S. Forest Products Laboratory

## Notes Specially Prepared for the Scientific American Monthly

### LAMINATED BASEBALL BATS

THE usual method of making baseball bats is to turn them down from solid squares of wood. Tests made by the Forest Products Laboratory at Madison, Wisconsin, have demonstrated conclusively that they can be made just as well out of thinner pieces of wood glued together, and then turned to shape.

Laminated bats turned out at the laboratory were put to use in baseball games during two seasons and proved highly satisfactory. Occasionally a bat broke in service, just as solid bats do, but in every case the break was due to failure of the wood and not to glue failure. Some players showed a preference for the laminated bats and used them at every opportunity; others were prejudiced against them. This was no doubt due in a large measure to the balance or "feel" of individual bats, which is perhaps the most important item to the player.

In the opinion of a well-known baseball coach, the laminated bats drove the ball just as well as the solid bats and were as good in all other respects. It seems thoroughly demonstrated, therefore, that to relieve a shortage of stock of the proper quality and size in ash and other suitable woods, baseball bats can just as well be made of thinner material glued together.

### CHEMICAL REACTION AFFECTS CASEIN GLUE

ALTHOUGH casein glues are highly water-resistant, they ultimately decompose when exposed to a damp atmosphere for a long time. For many months studies have been under way at the Forest Products Laboratory to discover the cause of this decomposition.

The decomposition study is still far from complete, but the conclusion has been reached that the decomposition of ordinary alkaline casein glues is not due to the action of bacteria or molds. It appears to be due entirely to chemical action of the alkali in the glue. This conclusion is based upon the following observations:

Increasing the amount of alkali in the glue increases the rate of decomposition when the glue is kept wet.

Glues containing no sodium hydroxide, although deficient in some important respects, do not decompose as rapidly as similar glues containing sodium hydroxide.

Cultures of molds and bacteria could not be obtained from decomposed alkaline glues.

Some chemicals which have antiseptic properties are found to improve casein glue, but this improvement is due to their chemical action rather than to their toxic properties.

Glues can be completely decomposed in a short time at temperatures above that at which bacteria can grow.

Further work is being directed toward the production of glues which will resist chemical decomposition and at the same time be impervious to the action of fungi and bacteria as well as moisture.

### SPLIT POSTS AND ROUND POSTS

IS A split fence post as durable as a round fence post? This is a question frequently asked of the U. S. Forest Products Laboratory. The fact is, one kind of post will last about as long as the other if the amount of heartwood is the same in both. But if the percentage of sapwood is increased by splitting the split post will be less durable, and if the percentage of heartwood is increased it will be more durable than a round one. Posts of spruce, hemlock, or any of the true firs are exceptions to this rule, because their heartwood and sapwood are about equally durable.

When posts are to be treated with creosote or other preservative, a round post is preferable to a split post, because of the comparative ease with which the sapwood can be treated. The heart faces on split posts do not, as a rule, absorb preservative well. Split red oak posts will take treatment because the wood is very porous, but the heart faces of split posts of many other species, notably white oak, red gum, and Douglas fir, resist the penetration of preservative, even under heavy pressure.

### EFFECT OF KILN DRYING ON WOOD-BORERS

A NEW advantage of kiln drying over air drying which the Forest Products Laboratory has discovered is that kiln drying is fatal to some, if not all, wood-boring grubs. This fact is of considerable importance to users of ash, hickory, and many other woods which are attacked by insects. Manufacturers using ash lumber, for instance, are much annoyed by the injury worked by the red-headed ash borer. Air seasoning has no effect on the activities of the grubs, but, according to test made by the laboratory on wood infested with them, any kiln-drying process which can be considered practical for seasoning ash of any thickness will put an end to the borers.

### TO STOP DOORS FROM SHRINKING AND SWELLING

THE fact that the top and bottom edges of a door are practically always left unfinished is largely responsible for their troublesome habit of swelling and shrinking. The exposed ends of the vertical stiles give the most bother, because wood picks up or gives off moisture more rapidly through surfaces cut across the grain than through those cut parallel to the grain.

If the doors in a house are to shut easily and fit tightly it is important that their top and bottom edges be protected by paint or varnish. If it is necessary to refit the door after it is hung, the freshly exposed surface should be refinished at once.

# Survey of Progress in Mechanical Engineering

## Prepared Under the Auspices of the American Society of Mechanical Engineers

### INDUSTRIES AND SUPERPOWER

By Harold Goodwin, Jr.

The cost of fuel and purchase of power for all the industries in the United States amounts to only about 2½ per cent of the value of the products and is only about 4½ per cent of the value of the materials going into these products. (These figures apply to the country at large and not to individual industries.) Nevertheless, the subject of power generation and distribution is, of course, of the highest importance.

As regards the determination of the future load Dr. George Otis Smith, Director of the U. S. Geological Survey, has pointed out that the steam engine has been the cause of centralization of industry, while electricity has already been the means of decentralization and the greatest mission of the superpower system should be the aiding of industry in its economic decentralization.

Chart, Fig. 1, shows the method of determining the limit of saturation of industries with power. The upper curve shows the growth of the total mechanical power and the growth which may be predicted for it in the future, while the next curve shows the proportion of the load which could be economically supplied by central station service. The lower curve shows the growth of central station power and the way its logarithmic extension would continue. It is evident that the limit of central station supply of mechanical power should be

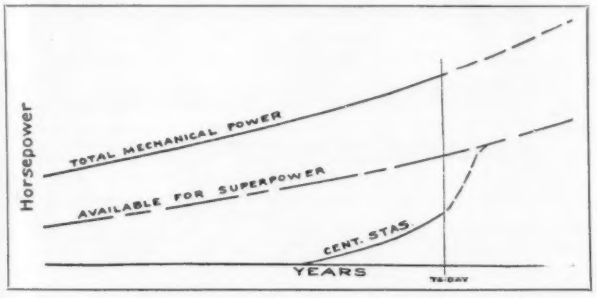


FIG. 1. GROWTH OF INDUSTRIAL MECHANICAL POWER

reached if the present rate of growth is maintained for a few years and that after the point of saturation has been reached the growth will be much more gradual.

This consideration would show that it is not safe to predict the load of the superpower system simply by the extension of the present growth curve of central stations.

The location of industries is determined by many factors, such as labor, transportation, raw material supply, etc. In some cases there seems to be a tendency for industry to move to the nearest supply of labor; while in others plants have made arrangements for drawing labor to them instead of carrying the plant to the labor. Availability of power through the superpower scheme may be of assistance in facilitating the location of plants on sites otherwise desirable. If there is a tendency of industry to decentralize, availability of power will be one of the controlling factors in the building up of new industrial centers.—*The Journal of the Engineers' Club of Philadelphia*, Vol. 38-2, No. 194, Feb., 1921, pp. 63-68.

### CENTRIFUGALLY CAST STEEL PIPE

By George K. Burgess

Abstract of a report of tests carried out by the author, in 1918, at the Bureau of Standards, on samples from hollow steel cylinders made by the W. H. Millspaugh process.

No data as to the process itself are given, except that the cylinders were cast in a machine revolving about its horizontal axis. The cylinders are said to have walls from ½ to 3½ inches thick. The outer surfaces were fairly smooth but the interior surfaces were rough. Plain carbon and nickel steel castings were investigated in the condition as cast and after various heat treatments.

Results of the radial surveys for hardness and chemical analysis show there is a gradual increase in carbon from the outside to the inside surface for all castings. This increase ranges from 0.02 to 0.09 per cent and appears to be roughly proportional to the carbon content, so that the percentage in variations remains practically constant. The nickel and phosphorus appear to follow the carbon very closely in their behavior as to segregation; manganese and silicon, on the other hand, are nearly constant across the radial sections, while sulphur, although somewhat erratic, in general, is distributed similarly to carbon.

The hardness surveys follow closely the chemical segregation, the higher numbers occurring on the inside layers. Stresses across section of tubes were measured by cutting out rings and it would appear that the internal stresses are of the order of the elastic limits of the material, the outer zone of the casting being in compression and the inside ring in tension.

Various attempts were made to improve these castings by heat treatment, the data being given in the form of tables. Most samples show good tensile strength for their composition and treatment and there does not appear to be any marked difference in values for longitudinal and transverse specimens.

Certain of these treated steel castings would appear to compare favorably with those of forged material of the same composition. For example the physical properties of some of the castings are equal to or better than ordnance requirements for gun forgings.

The only evidence of unsoundness of the metal was the presence of small blowholes in the inner zone, usually within 1/16 inch of the surface.

The microstructure of some, at least of these castings, is better than that of ordinary castings; certain ones show pronounced ingotisms (dendritic structure). The nickel steels contain more slag inclusions than is usual in ordnance steel, showing that this centrifugal process may not clear up a basic steel. The ingotism and coarse-grained structures of these centrifugal castings can, in general, only be removed by prolonged and repeated heat treatments, *i.e.*, normalizing followed by double quench and draw.—*The Iron Age*, Vol. 107, No. 12, March 24, 1921, pp. 764-766.

(*In this connection attention is called to an editorial in the same issue, p. 789, discussing centrifugal casting of steel as a metallurgical development which may become of importance.*—Editor.)

### MANUFACTURE OF WROUGHT PIPE FOR HIGH PRESSURES

For hydraulic purposes very strong pipe is required because the high pressures of hydraulic lines exert enormous bursting forces and the potential energy of the water under such working pressures closely approaches that of the thrust of a steel rod working as a piston under similar pressure.

The pipe must therefore be made with unusual care and furthermore to be efficient in the face of the friction developed by fluid flowing under enormous pressures and high velocities the pipe must be clean and smooth and must be capable of

bending without excessive distortion of the internal diameter. These conditions require that the pipe be welded and rolled according to the best mill practice and that the metal possess the usual combination of high tensile strength and great ductility.

The following practice is followed by the National Tube Company, Pittsburgh, Pa.:

To make pipe for hydraulic purposes, the solid ingot is rolled down to plates of the required dimensions which eliminates laminations occurring in plates rolled from built-up bars, and insures homogeneity of the pipe wall. Defects such as blister or blowholes are obviated in the skelp from which pipe is made by a mechanical process of working the metal in bloom form, known as Spellerizing. It is a kneading process which consists of subjecting the heated bloom to the action of rolls having regularly shaped projections on their working surfaces.

High-pressure pipe of smaller sizes is manufactured by the butt-welding process. The hot plate is welded into pipe at a point close to the end of the furnace by drawing through it a die shaped like a bell with a hole in one end. The pipe is reheated several times and drawn through dies having gradually decreasing diameters until the proper size is obtained. This is done in order to weld thoroughly the very thick abutting edges of the seam and to provide the necessary strength at this point.

When pipe is not intended for high-pressure service it is drawn through only one or two dies.

The larger sizes of pipe for high-pressure purposes are made by a process in which the edges of the plate are overlapped by the seam. The plates are properly rolled, heated and bent into rough tubes (skelp) and are then charged into a furnace where they are heated to a welding temperature. From the furnace they go into the revolving rolls of the welding apparatus, so grooved that they form a circular opening between them of approximately the same size as the outside diameter of the pipe. In this opening is a bullet-shaped mandrel and as a skelp comes from the furnace it is caught by the rolls which force it forward over the mandrel and press the overlapping edges together into a sound weld.

To make one length of the strong pipe used for certain purposes, two lengths of pipe are welded in this manner and then telescoped, this being arranged in such a way that the welds of the telescope pipes are at diametrically opposite points. In this position they are reheated to a welding temperature and are both passed at once through the welding rolls, thus forging them into a single length of heavy-walled pipes.

After the pipe has been welded it is passed through rolls which give it the required outside diameter and through cross rolls to straighten it and give it its true circular shape. The pipe is then slowly cooled on a continuously traveling table, after which the tags and the ends which have become damaged in manufacturing are trimmed off and the pipe is subjected to a hydraulic test to prove the soundness of wall and weld. The test pressures vary from 700 to 3,000 pounds per square inch according to pipe size and type of weld.—*Machinery*, Vol. 27, No. 8, April, 1921, pp. 755-756.

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## MICHELL CRANKLESS STEAM ENGINE

DESCRIPTION of a high-speed steam engine designed by A. G. M. Michell, inventor of the Michell thrust block for the purpose of testing whether by the use of these blocks it was practicable to construct crankless internal-combustion or steam engines, which would presumably be lighter than engines of conventional type.

In the Michell engine the crank is replaced by a swash plate which is not new in itself, but has not been done successfully in the past owing in the main to lubrication difficulties.

As the Michell bearings are good for a load of at least 500 lb. per sq. in. and have been used under loads many times greater, it was believed that they would help to get rid of the greatest difficulty heretofore experienced in substituting a swash plate for a crankshaft.

Fig. 2 shows the first such an engine. It comprises 8 cylinders, each 5 in. in diameter, arranged 4 on each side of the swash plate A, which is keyed to the driving shaft of the engine, which in its turn carries at each end a rotary valve B controlling the admission of steam to the cylinders. The engine works on the uniflow principle, the exhaust being discharged through ports C, of which there are eight for each cylinder, each 1⅛ inches in diameter.

The pistons on opposite sides of the swash plate are rigidly connected in pairs to form a single unit, the weight of the unit being adjusted to that of the swash plate so as to secure perfect running balance. (Formula given in the original article.)

The thrust of the pistons is transferred to the swash plate

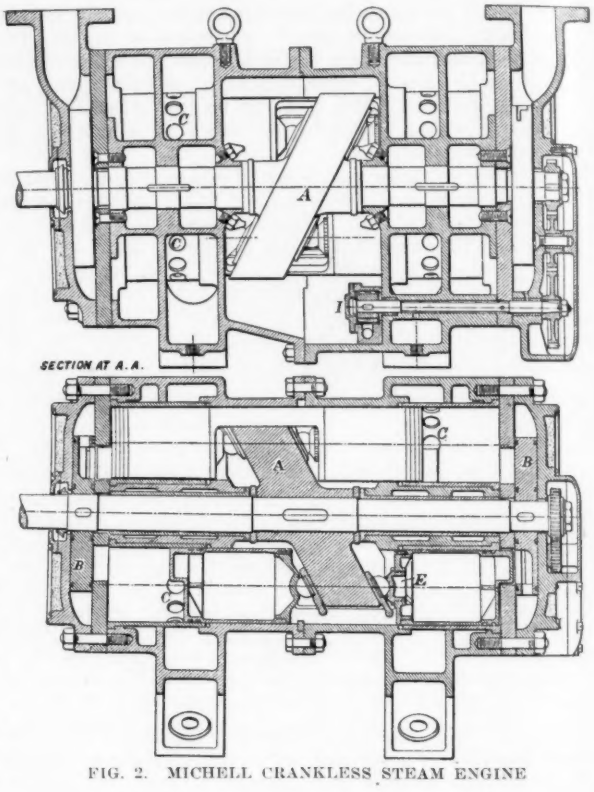


FIG. 2. MICHELL CRANKLESS STEAM ENGINE

through Michell blocks which are mounted on spherical seats and an ample supply of oil is maintained by means of a gear-driven pump.

Provision is made for adjusting the distance between the Michell blocks on opposite sides of the swash plates as at E. To the end in view one of the ball sockets is mounted on a screwed sleeve which can be adjusted by turning it by the notched head.

The engine was designed to run at 1,200 r.p.m. but the tests have shown that this limit can be greatly exceeded. In the tests the steam was supplied at 150-lb. gage pressure and exhausted to a condenser in which a vacuum of 26 inches was maintained.

The swash plate was held at an angle of 27½ degrees, but Mr. Michell intends to reduce this in future engines to 22½ degrees, since the tests showed that the larger angle was unnecessary. The horsepower developed was 0.92 i.hp. per cylinder per 100 revolutions, and it is believed the engine can be run at speeds up to 1,500 revolutions.—*Engineering*, Vol. 111. No, 2880, March 11, 1921, pp. 290-291.

# Progress in the Field of Electricity

## Summaries and Excerpts from Current Periodicals

By A. Slobod

### ELECTRIC DRIVE OF SHIPS

THE entire issue of the *General Electric Review* for February, 1921, is devoted to the subject of electricity on board ship. The question of electric propulsion is discussed by many prominent engineers. Mr. W. L. Emmet who has probably devoted more attention to this problem than any other engineer states that the applications of the system to naval vessels have given results in exact agreement with predictions, and a very large demand has been created for electric transmission equipments. The reasons why the General Electric Company has adopted this method of driving ships are that investigations have shown them that if the conditions of reversing and other matters are correctly allowed for, the electric drive gives a transmission efficiency practically equal to that of mechanical gears in their best condition, while it also greatly simplifies the turbine, saves space in ships, eliminates long lines of shafting, minimizes the risk of breakdowns, and facilitates the work involved in carrying out repairs.

The question of efficiency is quite important, and this is treated in a paper by Mr. Eskil Berg. The efficiency of conservatively designed double-reduction gearing, according to Mr. Berg, is about 94.5 per cent, and the loss incidental to the reversing turbine about 1.76 per cent, making a total loss of 7.26 per cent. There is also a loss in the reversing turbine itself due to the large clearances and to the fact that the reversing elements make the turbine longer, which necessitates a larger shaft and greater leakage loss between diaphragms as well as increased packing and bearing losses, and to this should be added the power taken by the various oil pumps required for lubrication. If for any reason the turbine is divided into high- and low-pressure parts, there are additional packing losses and a loss arising from the transfer of steam from one casing to the other, which may amount to 2 or 3 per cent. Taking a typical electrically-propelled ship of 3,000 shaft horsepower and with a shaft speed of 100 revolutions per minute, Mr. Berg fixes the motor efficiency at 95.65 per cent, including excitation, and that of the generator at 96.3 per cent, and allowing .04 per cent loss in the cable, the total loss is estimated at 7.93 per cent against 7.26 per cent for gearing. While it is admitted that there are many geared turbines running satisfactorily, it is asserted that a considerable number have given a great deal of trouble, and, on the whole, the writer is firmly of opinion that electric transmission is very frequently superior to gearing. It is of course well appreciated that it is on war vessels that the electric drive shows up to the best advantage. Economy at widely varying speeds is not nearly so valuable in the case of merchant ships; nevertheless other advantages of the electric drive are prompting its application to merchant vessels.

The closing months of 1920 gave birth to this innovation in the turbine electric drive of the merchant ships "Eclipse" and "Cuba." Some details are given by Mr. E. C. Sanders:

The "Eclipse" is a cargo vessel, the first of twelve vessels of the United States Shipping Board to be equipped with electric propulsion machinery. She is 440 feet long, 56 feet beam and of 11,868 dead weight tons. The propulsion machinery consists of a turbine direct connected to an alternating current generator which supplies power to an induction motor that is direct connected to the propeller shaft. A complete description of the control of the propulsion machinery is given in the article of R. Stearns in the same February issue of the *General Electric Review*. The performance of this initial installation on a cargo boat is gratifying. On November 9, 1920, the "Eclipse" sailed from New York for the Dutch East Indies and, after crossing the Atlantic in two days less than the regular schedule time, reported that all the equipment was operating satisfactorily and that the captain found great improvement in handling the ship in storm and in maneuverng in port.

The passenger ship "Cuba" is 320 feet long, 40 feet beam, and has a displacement of 3,580 tons. The principal difference between the propulsion machinery of this vessel and that of the "Eclipse" lies in the use of a synchronous motor instead of an induction motor for driving the propeller, with corresponding differences in the control equipment. On the official trial trip of this boat the propeller was brought from full speed ahead to a dead stop in two and one-half seconds and to full speed astern in seven and one-half seconds additional. The rapidity of this reversal brought the speed of the vessel from full speed to a dead stop in 140 seconds, which is considered remarkable in view of the fact that from four to ten minutes are required to stop the corresponding reciprocating engine-driven ship.

While up to the present nothing of a serious nature has happened to the early installations of the "Jupiter" or of the battleship "New Mexico," yet in the design of the latest alternators fitted to electrically-propelled vessels special precautions have been taken to protect the windings in the event of short circuits causing fire, and heating coils are fitted to prevent the accumulation of moisture on the windings when the machines are not in service. In the event of an internal short circuit occurring—which is said to be a very rare occurrence indeed—the ventilation damper is closed, and steam is admitted to the windings through perforated pipes fitted to the end shields, by which the fire is extinguished instantaneously. With these latest refinements and with a reasonable amount of care, the electrical installation is claimed to be practically immune from a complete breakdown which would leave the vessel stranded at sea. It is also shown in an article written by A. P. Badgley that in the case of induction motors some faults will not result in a complete breakdown if the machines are operated under the right conditions.

The Diesel engine electric propulsion is discussed by Mr. W. H. Wild, who gives its advantages and details of the first vessel so propelled—the "Mariner."

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### ELECTRIC FIRES

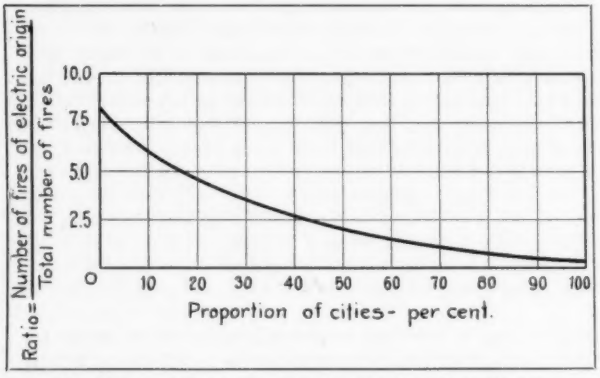
A GRAVE misconception concerning the number of fires attributable to electricity has been caused in the past five years by the widespread publicity given to the statistical compilations of fire losses by the National Board of Fire Underwriters. Electricity has been advertised, quite erroneously, as the most general cause of fires, the inference being that it is the chief fire hazard—the reason for the abnormally high annual fire loss in the United States—outranking even carelessness in smoking and in the use of matches which is given as the second hazard of importance, chargeable with a very considerably smaller loss than that due to fires of electrical origin.

The fallacy of placing any such interpretation on the records of the Fire Underwriters is made apparent by the exhaustive investigation which has been carried on by the Society for Electrical Development to ascertain the facts concerning fires which occurred in the year 1919 in communities supplied with electric service. Reports from 345 cities show that 138,553 fires occurred in 1919 of which those apparently of electrical origin numbered 3,568, establishing a mean fire ratio for fires of electrical origin of 2.57 per cent. This percentage differs sufficiently from the inferred electric fire ratio of the Fire Underwriters' report—about 6 per cent—and from the

even larger ratios frequently advanced to demonstrate forcibly the danger of accepting records compiled for special interests.

The discrepancy between the figures of the Fire Underwriters and those of the Society of Electrical Development is due entirely to method of approach and objective of the two investigations. The compilation of the Underwriters consists primarily of records of adjustments made on some 3,500,000 claims for damages occasioned by fires to which is added an arbitrary 25 per cent to cover unrecorded fires. It is essentially a record of private interests and consequently must be biased to a greater or less extent. The investigation of the society, on the other hand, has been based upon investigated reports submitted by fire chiefs, department, municipal and state officials, central station records and statements from special commissions in a very large proportion of the country supplied with electric service in 1919. These reports were investigated as carefully as possible to discover the full number of fires attributable to electricity and to eliminate from the records such fires as could be proved to be wrongly classified as of electrical origin and those which are known to have been confined to street cars, automobiles, poles, transformers, generators and motors and which did not therefore in any way affect property of private ownership.

As so many factors affect the prevalence of both the total number of fires and the number of fires of electrical origin which may occur in a given community, it has been found




MASTER CURVE OF FIRE RATIOS FOR ALL CITIES
62 per cent have fire ratios below 2.57 and about 90 per cent below 6

that the study of individual cities is of greatest value. The city of Chicago, for instance, reported through its acting fire marshal that in 1919 there were 14,407 fires, 562 of which were of electrical origin. This would give an electric fire ratio of 3.9 per cent which in view of Chicago's enormous electric load, might not be considered excessive. However, a careful investigation of all fire records made jointly by the engineers of the Commonwealth Edison Company and the city department of gas and electricity established the fact that the total number of fires known to have been of electrical origin was only 116. Even this relatively small number proved an over-estimate upon further investigation, as sixteen of the so-called fires turned out to be simply cases of motors or generators being burned out without other damage and six were due to short circuits occurring in automobiles on account of chafed tires. Thus, the total number of fires in Chicago attribuatable to the use of electricity was not more than 94—probably less—giving the city an electric fire ratio of 0.65 per cent.

## NEW PRESERVATIVE FOR WOODEN POLES

THIS preservative was invented by Malenkovic. It consists of 88.89 parts of sodium fluoride and 11.11 parts of dinitrophenolaniline (by weight). Comparative tests have been made of the durability of wooden telegraph poles impregnated with copper sulphate and of similar poles impregnated with this new preservative. The poles were treated under pressure with a 2.4 per cent solution of basilit in water till the wood had absorbed about 3 kg. of basilit per cubic meter. A statistical survey covering the performance of 4,000 poles during the years 1913-1917 indicated a spoilage percentage of zero in the first year, 0.09 in the second year and 0.12 in the third and fourth years, giving a total loss of 0.33 per cent for the four years. Similar poles impregnated with copper sulphate according to the Boucherie method and used under similar conditions during the same years showed a spoilage of respectively 0.11, 0.75, 3.26 and 6.23 per cent, or a total of 10.35 per cent poles in the four first years, which is thirty-one times as much as the corresponding figure for the basilit-impregnated poles.—Nowotny, *Elektrotechnik und Maschinenbau*, November 21, 1920.

## X-RAY EXAMINATION OF MATERIALS

A VERY interesting review of the recent application of X-rays is given in a paper of Mr. J. R. Clarke contributed to *Beama* for February, 1921. The author first reviews the fundamental principles underlying the X-ray apparatus and then discusses the production of X-rays. There are three sources of high voltage available, namely, influence machines, induction coils and transformers. The influence machine has been found unreliable and is very little used. After discussing at length the advantages and disadvantages of the induction coil and the transformer the author comes to the conclusion that if the X-ray installation is required for the continuous examination of heavy materials a transformer is preferable, but if light materials are to be examined, or heavy materials only occasionally, an induction coil will do the work.

The history of the other essential for the production of X-rays, the vacuum tube, is then briefly traced; the famous Coolidge tube is then described in detail and its advantages enumerated as follows: Formerly the intensity of the X-rays, which depends on the intensity of the cathode rays, could only be increased by increasing the potential difference applied to the tube and this also increased the penetrating power of the rays. In the Coolidge tube the intensity of the Cathode rays, and therefore of the X-rays, depends solely on the temperature of the tungsten spiral, and can be controlled by altering the resistance in the subsidiary heating circuit. The penetrating power of the rays is varied as before by changing the potential difference applied to the tube. In addition, as the cathode rays all proceed from the cathode, it is easier to focus them on the anode, and the focal spot does not move about as in the "residual gas" tube. The "softening" device is now unnecessary as is also the auxiliary anode. The anode itself is made of solid tungsten, because such a large amount of heat is developed by the impact of the cathode rays that a substance which is a good conductor of heat and which has also a high melting point is desired. If the discharge is too heavy or too prolonged even tungsten, the melting point of which is 3,000° C., may be fused.

After discussing the general practice of the X-ray application the author enumerates the various uses of the X-rays in industry. Probably the first industrial application of X-rays was their employment to locate pearls in oysters without opening them. The presence of pearl was indicated by the increased absorption of the rays. This examination has been abandoned, but the rays still serve the jeweler. By their aid he can distinguish real from artificial gems, the lead glass from which an artificial diamond is made, for example, being much more opaque to the rays than the real article. During the war extensive use was made of the rays for the examination of aircraft timber, spiral grain, hidden knots, resin pockets, grub holes and other defects in the raw material that can be recognized. Further, the soundness of assembled articles can be ascertained; a crack in the middle layer of three-ply wood can be detected. Another war application of the rays was the examination of innocent-looking and innocently-labeled consignments of goods for the presence of contraband of war. The X-ray examination of leather is a routine process in

some boot factories and sometimes the finished boots are also examined. Fiber for insulating purposes is frequently made from pulped rags and many contain metallic particles from a stray button. These particles can be detected and the labor involved in the manufacture of an insulator from faulty fiber can be saved. One of the most recent examples of the utilization of the rays in industry is the examination of chocolates for small pieces of metal or grit. In all these cases the examination can be carried out with a fluorescent screen, provided the objects to be examined are not too thick. Such articles can be carried on a belt between the tube and the fluorescent screen, and examined as they pass under the screen.

Examples of the materials which are examined photographically are quite as numerous. Light castings are examined for blow-holes. The soundness of welded joints can also be ascertained; in a bad weld the edges of the original plates can be seen on the photograph and blisters show up as light spots. The accuracy of assembly of metallic articles also calls for photographic examination. By this method, for example, it can be ascertained whether an insulated plate, such as is used in switchgear, is central with respect to the insulation. The material from which an article is made can also be ascertained. The mark on a steel casting may be machined off, but, as the various steels differ in transparency to the rays its identity may readily be reestablished. The thickness of the metal which can be examined in this way depends, of course, on its density. Gold being more than twice as dense as steel, the maximum thickness of gold which can be examined with any installation is less than half that of steel. The limiting thickness which can be examined at present is placed at various amounts by different workers. A pronouncement by Coolidge in this connection is interesting. He considers that it is practicable to make use of X-rays in the examination of steel having a thickness of not more than one inch. As the penetrating power of the rays available increases this maximum thickness will increase.

In addition to the uses of X-rays in the actual examination of materials, there is the moral effect upon the workman of the prospect of having his work so examined. If he knows that this examination will reveal that a weld may be bad, though the surface is good, he is less apt to neglect the interior of the weld.

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### AUTOMATIC HYDROELECTRIC PLANTS

WHILE a small station which cannot afford high class engineers for its control and operation may have been fairly successful when it was an isolated station, now, when tied into the large distribution systems which cover the country, a much higher safety factor of operation is necessary since any serious trouble may involve the entire system. Therefore, aside from the economy resulting from the saving of the cost of attendance, reliability of operation makes it preferable to control and operate such small stations at a distance from a large station which can afford the quality of attendance giving the assurance of first-class operation. With the present-day development of electrical engineering it is possible to make the operation of the small station entirely automatic and thereby take its control out of the hands of the rather indifferent class of attendants economically available for such stations. Thus the automatic hydroelectric station is not merely an advance in economy which makes the operation of small stations possible, but it is an equal advance in the safety and reliability of the operation of these stations and therewith of the systems into which these stations connect.—Dr. C. P. Steinmetz in *The Electrical Review*, March 12, 1921.

# Progress in Mining and Metallurgy

## Abstracts of Papers and Recent Articles

### Prepared Under the Auspices of the American Institute of Mining and Metallurgical Engineers

### BREAKAGE AND HEAT TREATMENT OF ROCK-DRILL STEEL

By BENJAMIN F. TILLSON

THE development of rock drills to the hammer-drill type in place of the old reciprocating piston drill probably is one important cause for the greater steel breakage. Perhaps the manufacturers of drill steel have failed to realize what alloys are needed for this new service or have overlooked the changes in the art of rock drilling. The mine operator may be at fault in desiring to use the smallest possible drill-steel section in order that the gage of the drill bits may be correspondingly small and the amount of footage drilled per unit of labor may be greater; or the blacksmithshop practice at the mines may need improvement. The miner who uses the drill steel may also require more intensive supervision and education. Again, the manufacturer of rock drills may have failed to study the types of blows the steel alloys will withstand satisfactorily and which their tools are delivering and so he may not know whether or not a different design of rock drill would equal or excel their present drilling speeds without treating the drill steel so severely. All of these hypotheses probably have their supporters.

On the other hand, perhaps we are seeking too much service from drill steel and we need a fuller realization of the fatigue strains developed and should prepare to relieve these by a periodic heat treatment of the steels. However, we do not find any proof that any of these suppositions may be held responsible for the drill-steel breakage attendant to mining.

The proposed investigation of this matter by the U. S. Bureau of Mines is fully warranted in the promotion of the conservation of labor and material, and the safety of the workmen. The great range of field conditions, as well as the scope of the reasearch, requires the energetic coöperative support of many interests.

In order to direct our attention to what are thought to be some of the salient features of this research, the following preliminary outline has been prepared:

1. Study of steels that give the greatest service before failure by breakage of drill steel: (*a*) Nature of sections; (*b*) composition; (*c*) methods of manufacture.

2. Maximum service that might be expected: (*a*) Life of steel; (*b*) methods of heat treatment; (*c*) standard methods for recording service.

3. Mechanics of failure: (*a*) Micro-analysis; (*b*) nature of stresses; (*c*) detection of incipient failure: (1) Magnetic analysis; (2) other methods not destructive of bar of steel. (*d*) Is failure due to fatigue of metal?

4. Methods and machine development for accelerated tests: (*a*) Nature of forces involved: (1) Impact; (2) vibratory compressional waves; (3) combined bending, vibratory, shearing, and torsional.

5. Correlation of field tests with accelerated laboratory tests.

6. Reclamation of depreciated drill steels: (*a*) Before failure; (*b*) after failure; (*c*) methods of heating: (1) Oil-fired furnaces; (2) electric furnaces: resistance (carbon or nichrome); induction (high-frequency or low-frequency); (3)

ohmic resistance methods. (*d*) Welding of fractured steel: (1) electric; (2) forge.

### LIFE OF DRILL STEELS

It is difficult to say what life or service should be expected from a bar of drill steel, as the conditions of field testing have many variables. However, within certain limits, we would probably agree to a minimum service. For instance, it would probably seem absurd that a ⅞-in. section of steel would not drill with sharp bits over 40 ft. of 1½-in. to 1¾-in. hole in pure limestone rock, before fracturing, yet some of the graphs accompanying this paper indicate poorer results. The maximum drilling recorded in these tests was about 281 ft.

### MECHANICS OF FAILURE

It is not necessary to mention the various reasons why the microscope is invaluable in considering the metallurgy of steel nor the methods involved in determining the unusual conditions in composition, grain structure, and impurities that may occur in the drill steels. For the detection of the stresses that cause incipient failure, it is necessary to prepare a polished face along the length of the entire bar of drill steel, to protect this face from oxidation with a coating such as amylicetate, and to use every care when testing this steel to destruction. Such a procedure permits the detection of the local development of slip planes that occur at the surface of the steel, but it seems difficult to detect those originating within the bar.

The belief that the breakage of drill steel is largely due to the so-called "fatigue" of the metal has many proponents, but others contend that the problem of fatigue is of no importance and that the steel fails through lack of a homogeneous suitable structure and that faulty manufacture or subsequent abuse are responsible.

### FORCES ACTING UPON DRILL STEEL

In order to get an idea of the magnitude of the forces acting on a drill steel, assume that a piston weighing 4 lb. makes 1,500 strokes per minute and travels 4 in. before it strikes the end of the drill steel; a drilling speed of 10 in. per min. advance of the drill steel in the rock, and a cross bit of 1¾ in. gage formed on the drill steel to cut the rock and rotated halfway around in an oscillating motion 50 times per minute, the cutting edges of the drill bit are formed by planes meeting at 90° and presenting a surface 0.005 in. wide when sharp. Then the penetration of the drill steel in the rock will be about 0.1 in. per blow. The kinetic energy of the piston is about 69 ft.-lb. and the total average pressure on the rock will be about 8,300 lb. if the compressibility of the piston, the drill steel, and the rock are ignored as relatively small factors when compared with the depth of penetration in the rock. The crushing strength of granite is estimated from 12,000 to 20,000 lb. per sq. in.; we will use 14,300 lb. per sq. in. If the initial pressure of contact of the steel against the rock equals this value, the final pressure would be 16,350 lb. or 22,800 lb. per sq. in. of drill bit in contact with the rock at the end of the penetration. This is about 60 per cent more than the pressure required to crush the rock, so a corresponding portion of the force of the blows does no useful work but would be returned as a reaction through the drill steel if both bodies were perfectly elastic. The coefficient of restoration of steel, however, is ordinarily given as about 56 per cent, so that the rock could not return quite all of this excess force as a reaction on the steel. If it is assumed that this steel has a modulus of elasticity equal to 29,000,000 lb. per sq. in. and a density of 489.6 lb. per cu. ft., the velocity of propagation of sound waves through it will be 16,550 ft. per sec., and as the time in which the piston is delivering its energy to the steel is 0.0005 sec., the wave lengths will be about 8,275 feet.

Among the principles that govern the transmission of compressional waves are the following:

1. When a longitudinal or compressional wave passes from one medium to another, a part of the energy is reflected and a part transmitted. The phase of that part reflected is changed one-half of a wave length when the reflection occurs in the denser medium. When the reflection occurs in the lighter medium the phase of the wave is unaltered.

2. Two waves of the same length, but differing in phase, combine to produce a wave of the same length but different amplitude and phase than either of the initial waves.

3. Two waves of the same period and amplitude, but differing in phase by a wave length, combine to produce a wave of the same length but double amplitude.

4. Two waves of the same period and amplitude but differing in phase by a half wave length mutually annul each other.

5. Two waves that differ slightly in length combine to produce a wave of varying amplitude. Its frequency is one-half the sum of its component frequencies. If both initial waves were of the same amplitude the amplitude of the resultant wave will vary from zero to twice the original amplitude as many times per second as the difference of their frequencies.

6. When two equal waves transverse in opposite directions, the resulting wave remains stationary. The node in the resultant wave occurs half way between the similar zero points of the original waves; and the points of greatest amplitude occur one-quarter of a wave length away. Therefore nodes occur at distances that are multiples of half wave lengths.—Abstract of paper presented at the New York Meeting, Feb., 1921, of the Amer. Inst. of Min. and Met. Engineers.

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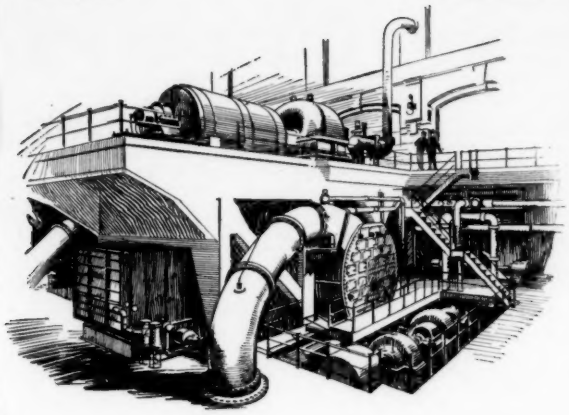
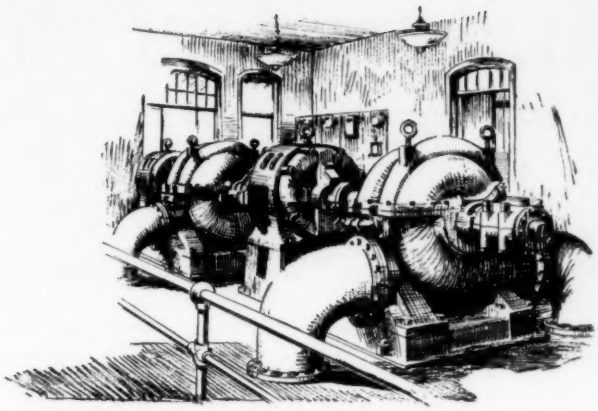
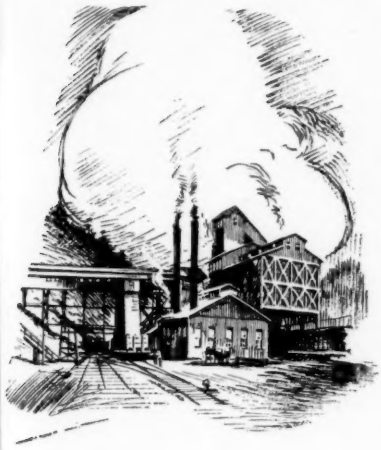
## CIRCULAR 20-FT. VERTICAL SHAFT 7,000 FT. DEEP

AN account of the scheme that has been adopted for working the City Deep mine at a depth of 7,000 ft. was given before the Institution of Mining and Metallurgy by Mr. E. H. Clifford. The mine is now being operated from two vertical rectangular seven-compartment shafts 4,000 ft. apart, 3,300 and 4,000 ft. deep, respectively. From the bottom of these shafts extend two five-compartment inclines which lie under the reef and are connected with it by cross-cuts at each level. The west shaft has reached the 20th level, and the east the 18th level. The vertical depth of the 20th level is 4,950 ft. The inclines will soon have reached the vertical depth at which troubles with rock pressure are likely to become serious, and their length will have reached the economic limit. There will thus remain an area equal to about one-third of the property which is not provided for by present appliances, and the scheme adopted in solution of the problem of exploiting it consists in sinking a vertical shaft of circular section 7,000 ft. deep in two stages of 4,500 ft. and 2,500 ft. The upper section will stop at the 17th level, where it will make connection with the two incline shafts, and the reef will be attacked from the lower section of the shaft by cross-cuts at each level. The shaft is 20 ft. in diameter in the clear, and is fitted with concrete rings spaced at 10 ft. vertical intervals. The rings are each 18 in. deep by 15 in. wide, and their function is to provide adequate fastenings for the shaft-guides, pipes, cables, etc., and also to afford a foundation for any form of lining that may be found necessary. The capacity required of the shaft is 2,000 tons of ore per 24 hr., plus all the men, natives, and materials necessary for this output. The cage is to be 15½ by 5¼ ft., with two decks, and will be made of alloy steel, as the saving in weight thereby effected will materially increase the working life of the winding ropes, diminish the consumption of power, and more than compensate for the additional cost. An existing double inlet Sirocco fan, 154 in. in diameter, with a capacity of 420,000 cu. ft. per min. at 2½ in. water gage, is now being run at only about half its capacity, and the surplus cooling power will be sufficient to offset the growing extension of the mine for a long time to come. Of the 300,000 cu. ft. that will be made to travel through the new shaft, 75,000 cu. ft. will be required to cool the electric winder and converter sets at the 17th level station, the remainder being directed through the lower shaft to the bottom workings.—Summary of paper presented before the Institution of Mining and Metallurgy.







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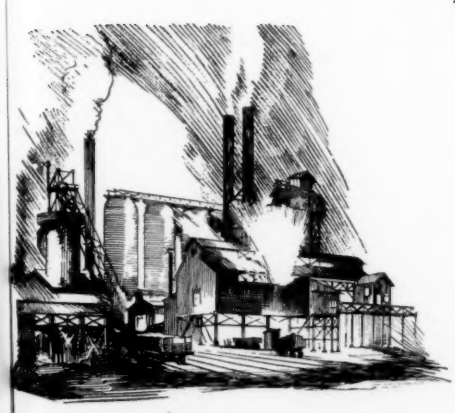

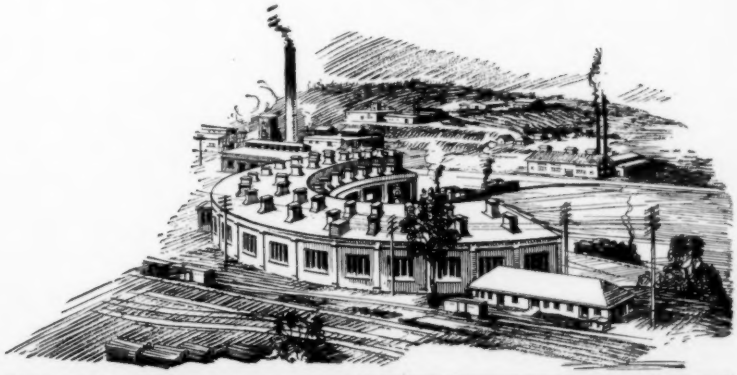

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PUMPS—COMPRESSORS—CONDENSERS—OIL & GAS ENGINES—METERS—MINING—ROCK CRUSHING & CEMENT MACHINERY

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